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INFORMATION FLOW AND TACIT KNOWLEDGE MANAGEMENT IN PRODUCT PLANNING PROCESS

Master's thesis

Examiner: Assistant Professor (tenure track) Tero Juuti
Examiner and subject approved by the Faculty Council of the Faculty of Engineering Sciences on 8th August 2018

ABSTRACT

SIRKKU SIMOLA: Information flow and tacit knowledge management in product planning process
Tampere University of Technology
Master of Science Thesis, 77 pages, 2 Appendix pages
October 2018
Master's Degree Programme in Materials Science
Major: Product Development
Examiner: Assistant Professor (tenure track) Tero Juuti

Keywords: learning organization, data flow diagram, knowledge management, tacit knowledge

This thesis focuses on the new product process, information that is created in it and its flow. The process owner is product planning organization in a steel company. Four years ago a lot of valuable information was lost in the personnel reductions after a merge. The literature review studies organizational learning and forgetting, tacit knowledge management and process models.

Research strategy is case study. Using literature review, company's internal documents and arranged workshops the current state of the new product process is described and a data flow diagram is drawn. Based on the data flow diagram and literature review development suggestions are given to be able to develop the process by the principles of learning organization and tacit knowledge management.

As a result there is information on the new information that is created during the new product process, what IT systems are used to transfer the information and which organizations are taking part in the process. In addition a result is knowledge how the tacit information could be transferred into explicit and saved and especially how a process model can be utilised in it.

TIIVISTELMÄ

SIRKKU SIMOLA: Tuotetiedon virtaus ja hiljaisen tiedon hallinta tuotesuunnitteluprosessissa
Tampereen teknillinen yliopisto
Diplomityö, 77 sivua, 2 liitesivua
Lokakuu 2018
Materiaalitekniikan diplomi-insinöörin tutkinto-ohjelma
Pääaine: Tuotekehitys
Tarkastaja: Assistant Professor (tenure track) Tero Juuti

Avainsanat: organisaation oppiminen, tietovirtakaavio, tiedon hallinta, hiljainen tieto

Tutkimus tarkastelee uuden tuotteen prosessia, siinä syntyvää tietoa ja sen virtausta teräsyhtiön tuotesuunnittelussa. Yrityskaupan jälkeisissä henkilöstövähennyksissä neljä vuotta sitten organisaatiosta menetettiin arvokasta hiljaista tietoa ja vastaava tilanne haluttaisiin välttää tulevaisuudessa. Kirjallisuuskatsaus tarkastelee organisaation oppimista ja unohtamista, hiljaisen tiedon johtamista sekä prosessimalleja. Prosessimalleista tutkitaan erityisesti virtausmalleja.

Tutkimusstrategiana käytetään tapaustutkimusta. Kirjallisuustutkimuksen, yhtiön sisäisten dokumenttien ja työpajojen avulla kuvataan prosessin nykytila ja piirretään tietovirtakaavio. Kirjallisuustutkimuksen ja tietovirtakaavion pohjalta annetaan prosessille kehitysehdotuksia, jotta prosessia voitaisiin kehittää oppivan organisaation ja hiljaisen tiedon hallinnan suuntaan.

Työn tuloksena on, mitä tietoa uuden tuotteen prosessin eri vaiheissa syntyy sekä mitkä organisaatiot ovat osana prosessia ja mitä IT-järjestelmiä tiedon siirtämiseen käytetään. Lisäksi tuloksena on tietoa, kuinka prosessissa syntyvää hiljaista tietoa voidaan muuttaa näkyväksi ja tallentaa, miten prosessimallia voidaan hyödyntää hiljaisen tiedon tallentamisessa.

PREFACE

Before starting my master's thesis I had worked at SSAB/Rautaruukki altogether over three years, in three different positions. The last one of these positions in product planning was definitely the most challenging one due to its complexity. Product planning is the node of the colour coated products and the tasks in it have changed a lot during the last years.

I was delighted that I was able to start my thesis to product planning. It was motivating to be able develop the work I had done myself the last one and a half years. For this opportunity and for great support I'd like to thank especially my foreman Pasi Köykkä and my colleague Leena Äikäs, who both showed a lot of interest to my work. Big thanks also to my other colleagues at SSAB who have been part of forwarding this thesis.

Although it was challenging to start studying after working full-time for quite a while, it was rewarding to notice that I still had some routines left from the studies that I started eight years ago. However the thesis was a learning process: I learned skills of a scientific author and project manager as well as of a coach. Amongst other things, I give thanks to my examiner Tero Juuti for the foregoing. He also helped to form the thesis from a rough sketch.

Lastly I want to thank my carpool colleagues, 'camelgirls' and my husband Niko for tolerating the long sighs and giving golden advice and my assistant cats for relieving stress.

In Hämeenlinna, Finland, on 19 October 2018

Sirkku Simola

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LIST OF SYMBOLS AND ABBREVIATIONS

DFD	Data Flow Diagram
ECI	Exceptional Customer Inquiry
PCP	Product Commercialization Process
SC	Sales Configurator
SCM	Supply Chain Management
TCS	Technical Customer Service at SSAB
TDM	Technical Development Manager, works in TCS organization

1. INTRODUCTION

Mergers, acquisition and alliances have been a growing trend and a widely used business strategy in the last decades as it can be seen in figure 1. (IMAA 2018) Although it is trending it doesn't mean it would be easy. There are many challenges when two or more companies unite. Old manner of proceeding with mergers and acquisitions was that the board of managers made the agreements, but the actual responsibility to run the unification were shifted to the ones that had nothing to do with the deals and agreements (Parry 2011).

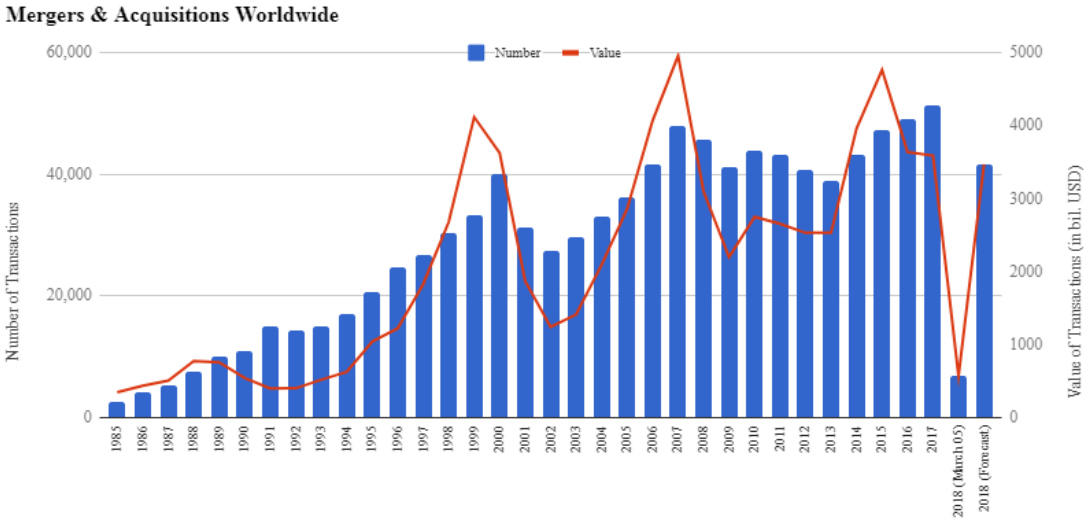


Figure 1. The number of mergers and acquisitions worldwide (IMAA 2018)

Big companies usually have several processes that are administered by different organizations. This causes challenges to the comprehensive administration of the process in particular if a specific process description is missing or the process doesn't have an owner. This is emphasized especially after company merges when there are parallel processes from both old companies that are tried to amalgamate. After the merger it is rarely remembered that on the employee level there are still two networks, servers, policies and standards of working on top of the different tools and IT systems. Of course, the goal is to have harmonized lines of action at some point, but big differences in management of systems and information can be a barrier for the harmonization especially if it is not done soon enough. (Wilson 2004)

In 2014 SSAB AB acquired Rautaruukki Oyj ("Ruukki"). The companies were quite like each other by the figures. Both focused on carbon steels, Nordic based – Ruukki in

Finland and SSAB in Sweden – and approximately 8700 employees in both. (European Commission 2014) In consequence of the merger also some organizational changes were made to reduce overlapping functions. During the first three years after the merge the plan was to reduce approximately 5% of the employees (SSAB 2014). Due to that some processes were spread quite widely into different organizations and data systems while the one key organization responsible for the process was lost. That meant also the loss of large amount of tacit knowledge. One example of this occurrence is product planning. This thesis focuses especially on product planning organization and a process called new product process.

In this thesis the theoretical part consists of a literature review on learning organization and how to control tacit knowledge. On top of that a view of different process models is presented. The theoretical part is followed by the empirical part which is based on facilitated workshops. In that part also, the data flow diagram (DFD) for the process in scope is formed. Finally, a goal is to give tangible proposals how to develop the new product process. Another goal is also to find a way to create a process for saving the future tacit knowledge. The goals and the structure are introduced more detailed in chapters 2.1 and 2.3.

2. DESCRIPTION OF THE PROBLEM AND OBJECTIVES

As discussed in the last chapter, organizations have been reformed and tacit information has been lost in the company. This has caused a need for description and clarification of the new product process. There is also a need to discover the roles of the different organizations in the process and the possibility to simplify it. At the moment at least five different organizations are involved in the new product process. The new product process is described more detailed in chapter 5.2.

To be able to develop the process, the current state of the process has to be studied. On top of the need to develop the process there is also a need to create a process for transforming tacit knowledge into explicit information. That is to avoid the loss of tacit information in the future.

In this chapter the problem and research questions, research methodology and strategies, the scope and the structure of the study are described.

2.1 Objectives and research questions

The goal of the theoretical part of this thesis is to gather information first on tacit knowledge and learning organizations and second on process models to support the empirical part. In the theoretical study the goal is to find answers how the new information formed in the process iterations could be saved, what are the benefits of process model and what would be the most suitable model type for this purpose.

The practical goals of this thesis can be summarised into two main goals. First is to find the critical tacit information that is formed in new product process by creating a process model that has been contributed by engaged organizations. Second goal is to give a development proposal for developing the new product process to further the information transformation from tacit to explicit, to meet the principles of SSAB One and reducing the complexity of the new product process by analysing the process model. The basics of SSAB One can be found in chapter 2.1.1.

According to Saunders et al. (2009) and Hirsjärvi et al. (2011) the research questions are one of the most important things when planning a research. Good research questions and answers to them should also provide new insights.

The needs presented in the beginning of this chapter shape the research problem on the background of this thesis. From that problem the main research questions are formed:

- What kind of information is generated in different phases of the new product process?
- How can the tacit information, which is generated during the process, be saved?

To ease the answering to the main research questions three sub-questions have been formed:

- What kind of information and IT systems and which organizations are involved in the new product process?
- How can tacit information be transformed into explicit?
- How can a process model be utilized in saving tacit information?

On the grounds of the theoretical study and the analysis of the empirical part the sub-questions can be answered independently and trough those answers it is possible to form answers to the main research questions.

2.1.1 SSAB One

In short SSAB One is about improving the work flow based on customer needs and above all that employees get to participate in the improvements. SSAB One has a lot in common with the management philosophy of Toyota, but it is based on SSAB's own history and views. There are four principles in SSAB One that can be found in figure 2: customer demand driven, normal state, right from me and learn and improve.

Figure 2. The vision, values and principles of SSAB One (SSAB A 2017)

How the principles are present in this thesis? Customer demand driven – the goal of each process is to serve its customer the best way possible whether the customers are internal or external. The second principle is to create a normal state, to establish the working methods so that it is easy and fast to detect any deviation or defect. Right from me stands for preventing the mistakes or defects to flow forward in the workflow, trying to understand the root causes and developing better ways of working. Learning and improving means the basic daily works, making small steps towards better work. Development is everyone's responsibility.

One of SSAB One's targets is to reduce loss. The eight types of loss are overproduction, unnecessary movement, unnecessary storing, defects and redoing, unnecessary transportation, waiting, over processing and untapped creativity. Untapped creativity in this case means everything that is preventing one to take part in developing. (SSAB A 2017) Those losses and principles are the base by which the development suggestions in this thesis are made.

2.2 Research scope

In qualitative research there is not a population that would eventually be studied thoroughly. Instead, qualitative research gives new viewpoints to the subject. Basically, there are endless options to qualitative research of a subject which is why it is very important to define the scope of the research carefully. (Eskola & Suoranta 1999)

The scope of the theoretical part in this thesis is titled to be learning organization, tacit knowledge management and process models. This thesis focuses particularly on learning that is present in the process in question. Because of that learning between organizations and learning from competitors have been left out. More precisely the focus is on tacit knowledge connected to organizational learning. Innovation is usually thought to be inventing something totally new. According to Hislop (2005) innovation is a knowledge creation process which belongs to knowledge management. Despite Hislop's theory, in this thesis innovations are not handled.

King (2009) describes organizational learning to be the goal of knowledge management. In other words, knowledge management is needed to reach a learning organization. In this thesis the concentration is especially on tacit knowledge management. How tacit knowledge is created, how should it be stored and used. By organizational learning it is possible to merge the knowledge that is already in organization to the processes inside the organization to develop the operations and to reach the goals. (King 2009)

The process model is applied in the empirical part when a data flow diagram is drawn up. The model is answering the research question "What kind of information is generated in different phases of the new product process?" In detail the model consists of what information we need and where do we get it from to have a product accepted in production. The model includes the information source on organizational level and the different IT systems that are used to transfer the information. Product planning and its activities are presented more thoroughly in chapter 5.1. Since the need was to define which information is needed and which IT system are used to transfer it the process model concentrates particularly on information or data flow instead of work flow, material flow or control flow, as Lehtonen et al. (2012) divides them.

The scope of the empirical part of this thesis is called new product process at SSAB's product planning organization. The point of view is especially product planning organizations' viewpoint. Other organizations that are involved in the new product process are considered, but the main focus is in product planning activities. This thesis considers only the before mentioned process at SSAB without including other similar processes in other companies from the same field. The results of this thesis can be partially applied to other businesses and processes, but it is not the intention of this thesis.

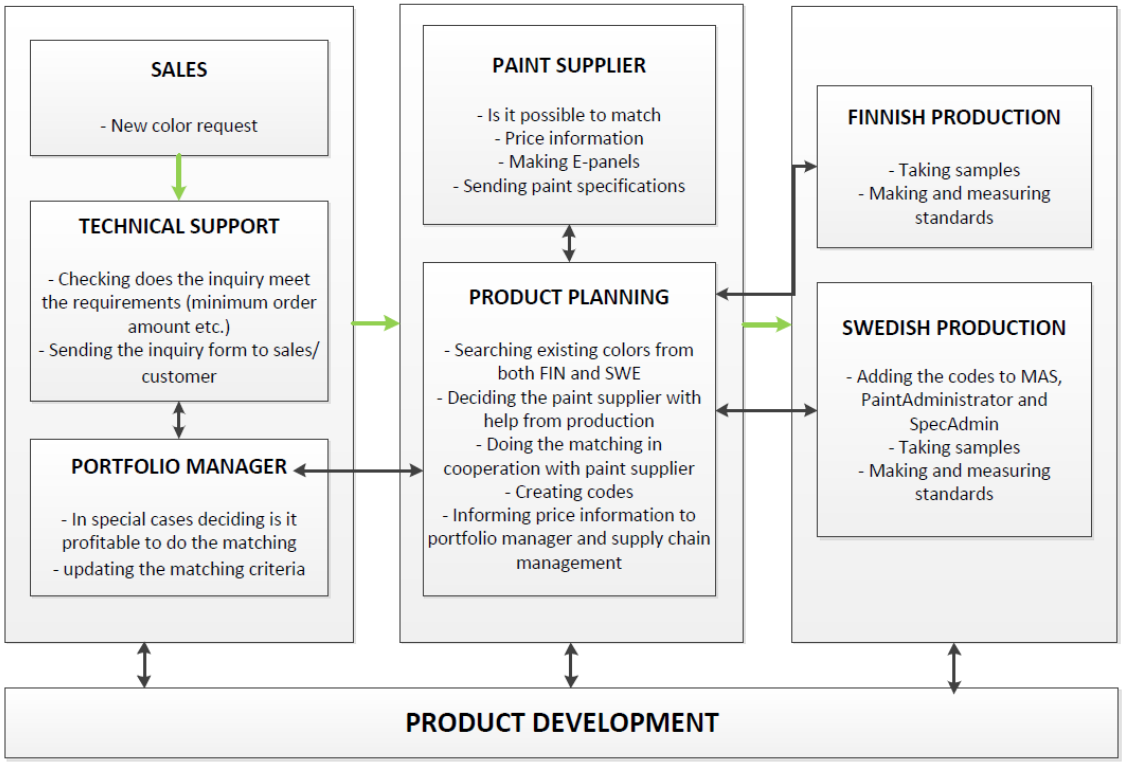


Figure 3. Process chart of new product process made in 2016

The process in scope is presented in figure 3. The process chart in figure 3 does not represent the present state, but the insights from two years ago. Since then the process has changed and an updated version is undone. The process starts from the sales or from the customer with a request of a new colour and ends either with decision not to do the new product or when the order is in the factory systems. The aim of this thesis is to find out what happens in between and in which IT systems. The new product process is described in chapter 5.2.

2.3 Structure of the study

As it can be seen in figure 4, after the introduction in chapter one and the description of the problem and the objectives presented in this chapter, next chapter is handling the research methodology, including research methods, research strategy and data collecting procedures and analysing methods. The purpose of the chapter three is to illustrate how the research is conducted. Chapter four includes the theoretical part with a literature review. In that is studied how the tacit information appearing in organizations could be saved to form a learning organization. In addition of the tacit information and learning organizations, process models, especially data flow diagrams are studied.

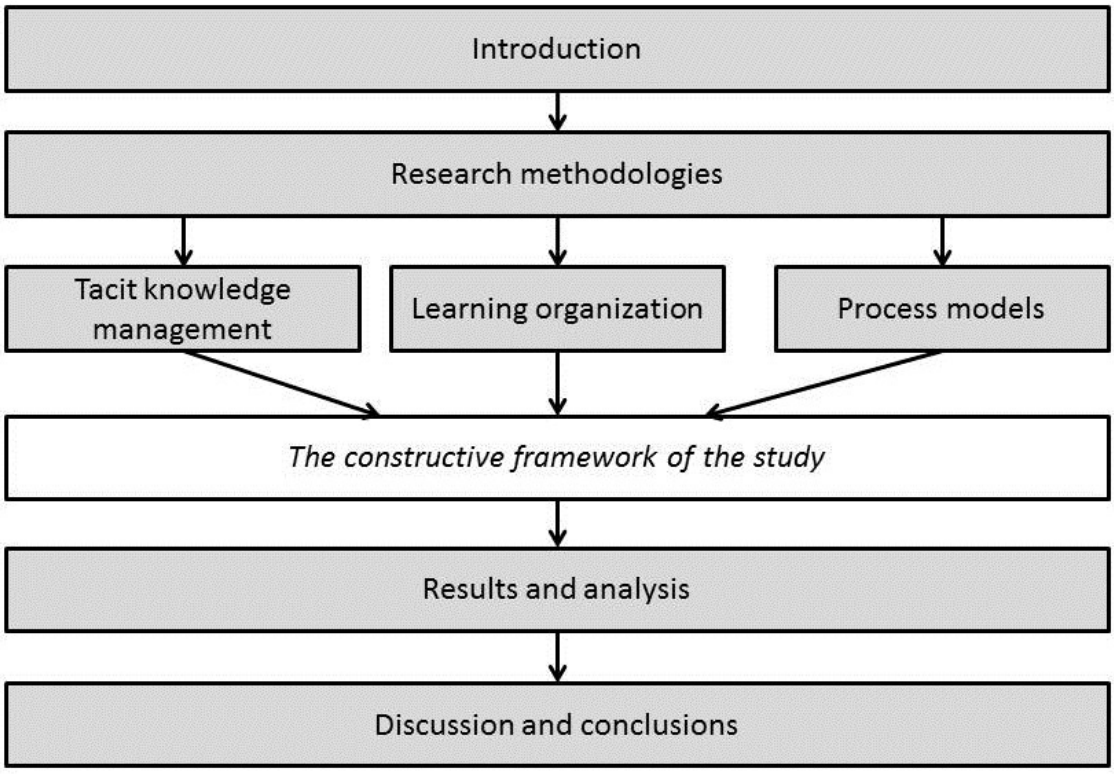


Figure 4. Structure of the study

From the chapter five forward the thesis focuses on the empirical part. Chapter five represents the objective company and the process in scope. After that in chapter six the collected data is analysed followed by the results of the analysis. Chapter seven considers the answers to the research questions and the evaluation of the results and implementation of the study. Discussion can also be found in chapter seven where reaching the goals is examined. Furthermore, the novelty, reliability and validity of this study are being evaluated. In the appendix A there is the complete data flow diagram of the new product process and in appendix B there is the full data and work flow diagram.

3. RESEARCH METHODOLOGY

There are several ways how to group different researches and research methodologies. Saunders et al. (2009) do it first by research philosophies and approaches followed by strategies, choices and time horizons concentrating especially on business researches.

The choices made concerning research philosophy, approach and strategies are highly affected by the assumptions how the writer views the world. The same choices have also significant effect on the implementation of the research and its results. (Saunders et al. 2009) This is why it is important to be conscious about that when analysing the research results.

First section presents the main research philosophies and approaches to the research. Second introduces the research strategies and methods and the ones that are used in this thesis. Section 3.3 describes data collecting methods that were utilized.

3.1 Research philosophy and approach

According to Saunders et al. (2009) research philosophies can be divided into four main groups: positivism, realism, interpretivism and pragmatism. Olkkonen (1994) uses the following two instead: positivism and hermeneutic, that is sometimes referred as a variation of interpretivism.

Positivism concentrates on immediate observations and avoids any interpretation and suppositions. The research is not depending on the researcher and is repeatable (Olkkonen 1994; Saunders 2009). Realism is close to positivism, it doesn't consider any interpretations, only direct sense perceptions (Saunders 2009). In interpretivism everything depends on the interpretation. The research depends a lot from who is the researcher. (Olkkonen 1994, Saunders 2009) Also hermeneutic philosophy concentrates on meaning, understanding, and interpretation (Olkkonen 1994). Pragmatism is somewhere between positivism and interpretivism. According to pragmatic philosophy it is not possible to choose just one of the two: interpretivism and positivism (Saunders 2009). The philosophy of this study is somewhere in the middle ground of interpretivism and pragmatism. The researcher works in the organization that is research object so fully objective interpretation would be very challenging. But in the same time to aim is to be as objective as possible.

Approaches all four: Saunders et al. (2009), Hirsjärvi et al. (2011), Olkkonen (1994) and Uusitalo (2001) present in two categories: deductive and inductive. A research rare-

ly uses only either of the before mentioned, usually both are used but either of them is emphasized. In deduction a predefined theory is tested. For example, a hypothesis is formed via smaller sampling and then tested with a larger research. Only logical conclusions are made instead of suppositions in deductive research. In inductive research usually, qualitative data is collected, and the main goal is to understand the object of the research. (Uusitalo 2001; Saunders et al. 2009) Sometimes a third approach is also mentioned: analogy. Logic is used in analogical approach to get a probability for a certain property. (Olkkonen 1994) This research is concentrating on the inductive side, since there is no hypothesis or theory to begin with. As presented in the previous chapter the approach to this study is to observe the process and try to represent it as detailed and realistic as possible.

3.2 Research purpose, strategy, choices and time horizon

The term research strategy in itself is wide and it is defined differently depending on the literature reference. Lähdesmäki et al. (2014) considers research strategies as principles that guide the implementation of the research. Methodical decisions of the research form a whole that is termed research strategy. The chosen strategy directs the choice and use of the research methodologies both in theoretical and practical level. (Lähdesmäki 2014) The chosen strategies, research choices and time horizons are also tools to turn the research questions into a research project, a plan how to get answers to the research questions. (Saunders et al. 2009)

There are research purpose categories and all the strategies can be used in any of the following three purposes: exploratory, descriptive and explanatory. Exploratory purpose rarely gives answers to the research questions and is usually used in a pre-study phase. Descriptive researches on the other hand are often statistical. They describe the current state of the research subject. Explanatory research is not so easy to distinguish from descriptive research. Roughly explained the difference is that descriptive research answers questions like what or how and explanatory research answers to why questions. (Saunders 2009; Uusitalo 2001)

Strategies Saunders et al. (2009) divides into seven categories: experiment, survey, case study, action research, grounded theory, ethnography and archival. Experiment studies how a change in one variable effects on the other variables. It usually deals with how and why questions. Survey is used when collecting large amount of data from a decent sized population, usually via questionnaires, structured observations or structured interviews. (Saunders 2009) In action research the research team is making an action and then evaluating how it affected on the research subject. Grounded theory is based on collected data, forming a theory from the data and then testing the theory by collecting more data. Ethnography concentrates on the social world the research subjects are living in and archival research studies already existing data. (Saunders 2009)

Case study according to Robson (2002) involves “empirical investigation of particular contemporary phenomenon within its real-life context using multiple sources of evidence” (see Saunders 2009) which summarizes also Yin’s (2009) view. Yin also adds that case study answers questions how and why. Lukka (2001) on the other hand is of the opinion that case study is more an umbrella term that includes several different strategies instead of one research strategy.

Saunders (2009) divides case studies in to four different categories that might also overlap each other. Single case has as the name suggests only one case that is studied and contrary to single case multiple cases has several cases under research. Holistic case has one unit of analysis and in embedded case there are numerous analysing units. (Saunders 2009)

Lukka (2001) suggests that one type to perform a case study is to use constructional framework. Constructional framework is a methodology that aims to solve a real-world problem by innovative constructions; a tool or a method to solve a problem. Constructive research is common especially in technical and medical researches. (Uusitalo 2001)

This study is concentrating on one single case in a company. The goal is to describe the process and by analysing the process to form development suggestions. In other words the objective is to increase understanding on the research object which leads to descriptive research purpose in a single case study that uses constructive framework as a tool to reach the set goals.

The research choice of this thesis is qualitative mono method study. In qualitative research there is not a population that would eventually be studied thoroughly. Instead of that qualitative research gives new viewpoints to the subject. (Eskola & Suoranta 1999) Earlier the mind-set has been that research is always either qualitative or quantitative. Lately the way of thinking has slowly turned to a direction that both can be used in the same study. The research problem is determining which choice to use. One research might have several research problems of which some needs qualitative methods and others need quantitative. In general, quantitative research measures something numerical quantity whereas qualitative studies meanings and contexts. The closer the research is to an individual the more likely qualitative methods are suitable. Hirsjärvi et al. (2011)

Cross-sectional is a snapshot of the time being. It is a picture of the times of state of the process on that moment. (Saunders 2009) Longitudinal Saunders et al. calls a diary perspective since it describes the state of the process in time interval, not just a single moment. This study belongs to the first one; the study is a cross-sectional picture of the current state of the process.

3.3 Research material collecting and analysing methods

The research material for this thesis is gathered from three different sources. First ones are the internal documents of the company. They include valuable information about processes, policies and working methods that cannot be found anywhere else. Second source is literature review on the subject. It includes existing documents as books and scientific, peer evaluated articles.

Third one is the workshops arranged where most of the new information was created or made from tacit to explicit. The basic aim for the workshops was to create templates and drafts of the future data flow diagram. Workshops were carried out in one or two phases. If it was done in two phases, in the first one the job descriptions of the participants and their part of the new product process were discussed. Researcher made notes from all the discussions. The aim was to survey the participants' duties and especially IT systems in use as thoroughly as possible. For the second phase the researcher picked up the relevant duties and IT systems regarding the new product process from the notes and formed a draft of DFD and also a separated list of the participant organization's needs. Examples of the drafts are presented in figures 5 and 6.

NEW COLOUR

Information needed	**Source organization**	**IT system FIN**	**IT system SWE**
Chosen suppliers	Product planning	IMS	MAS + Paint admin
Paints in use	Product planning	IMS	MAS + Paint admin
Layers, painting order	Product planning	IMS	MAS
Film thicknesses	Product planning	IMS	MAS + Spec admin
Protective film	PP / RD	IMS / Lotus Notes	MAS + SAP
Supplier code (levnummer)	PP / RD	IMS	Paint admin
Colour code	Product planning	IMS	Paint admin
Product code (paint + colour +	PP / RD	IMS --> Arttu --> SAP	MAS + Paint admin
Paint price, DSC%, density	Product planning	excel: D-form	excel: D-form
Paint yield	Product planning	email --> IMS	?
Campaigns	PP / RD	excel: PISU	MAS
Paint card	Product planning	IMS	
Coating card	Product planning	IMS	
Article number / Paint code	PP / RD	IMS	MAS + Paint admin
Spec number / Coating code	Product planning	IMS	MAS + SAP
Order information	Sales / Order handling	IMS	SAP

Figure 5. A part of the list of information needs of production planning regarding new colours in new product process.

PAINT SUPPLIER	PRODUCT PLANNING	PRODUCT SERVICE	PRODUCTION PLANNING	PRODUCTION: QUALITY TECHNICIANS / ENGINEERS	NEEDED DATA
					Design color inquiry
					- Application / wanted properties --> coating
					- Gloss level
					- Colour reference
					- Annual tons / m2
					- Steel, width and thickness
	Responsible				- Price extra, price of the product
					D-form
					- D-number, E-number
				Double-check (FSP)	- Colour standard (visual and measurement system)
			Needs this info		- Production line
					- Fire classifications
					- Environmental certificates etc.
					- Product specification
					Paint supplier information
			Needs this info		- Paint price, DSC%, density
				Needs this info	- E-panel
					Product Management
	Codes into IT				- Product names, colour names
					- Data sheet

Figure 6. A part of a DFD draft made in a workshop.

When forming a process chart or similar models Fountas et al. (2006) specifies that to meet the real world the model should answer following questions:

- "What information is required to carry out the activity, the source of this information and its form and frequency?
- What information is generated from the activity and the generated information's characteristics?
- Who is the recipient of this information?" (Fountas et al. 2006)

The Fountas' logic was used in building the DFD and the information needs list can be summarized into four questions that were discussed in the workshops:

- What information is needed in this organization?
- Who needs it?
- Where the information comes from?
- What IT system is used to transform / edit / transfer the information?

In the second phase the two drafts were gone through with the same participants to make sure that the researcher had understood correctly and to be able to add or change answers. It was also a chance to let the participants see the concrete model, what kind of a model DFD is. Sometimes the schedules were not enabling two sessions. In that case the same routines were completed, but instead of notes the researcher filled straight in the DFD draft. Later the final version of DFD was also sent to participants for commenting.

The participants to the workshops were chosen via purposive sampling. Purposive sampling works best for the case studies where the sample is small which in this case is

(Uusitalo 2001). Purposive sampling belongs to the group of non-probability sampling which means that the samples are not chosen randomly. Researcher chooses the cases that he/she thinks are to most suitable for the research and to get answers to research questions. (Saunders 2009) In this study the sample represents only the process in scope so the results cannot be generalized to whole population and neither is that the goal of this thesis. The participants were representatives from the key organizations that product planning co-operates with. All had a comparably long experience of working at SSAB or Ruukki and knew well the current and some historical working methods and IT systems. The participants and their organizations are presented below in table 1.

Table 1. DFD workshops and participants

DATE	PARTICIPANTS	CONTENTS/ORGANIZATION
23.-24.4.2018	Å. Pettersson, I. Nordin, T. Skotte, P. Johanson	Finspång's product planning, quality technicians and production
14.5.2018	K. Ahvonen	Product Management
16.5.2018	K. Laurila, A. Markkula, J. Lehtonen	Product Development
17.5.2018	K. Ollinkangas, O. Pasma	Hämeenlinna's production planning
17.5.2018	P. Köykkä, J. Ahokas, L. Lindqvist	Process Development
18.5.2018	H. Kapanen, H. Vekka	Hämeenlinna's production
21.5.2018	O. Sjödahl, J. Papp	Product service
22.5.2018	M. Olofsson, J. Stiwne	TCS / Sales
23.5.2018	L-E. Stenberg, T. Roininen	System support
25.5.2018	L. Äikäs, A. Kopio, T. Väliaho	Product Planning
30.5.2018	T. Sillanpää, S. Viitanen	Kankaanpää's production planning and quality
31.5.2018	E. Kauppinen, H. Sipilä	SCM

The role of the researcher in this study was both practitioner- and observer-researcher. The observer role is suitable for delineating and understanding operations, actions and behaviour (Uusitalo 2001). It works well in natural conditions and environments and usually it includes free interaction between the researcher and research subjects. A challenge in having an observer-researcher role is how much of the research the researcher should reveal to the research subjects. In this thesis a structured observing method was used. In that method the problem is already outlined so that the observing can concentrate only on the chosen features.

Practitioner-researcher (Saunders et al. 2009) is common when the researcher is working in the research subject organization. Pro of being a practitioner-researcher is that he or she has knowledge of the organization and the ways of working, but the con side is that the researcher probably has some assumptions and preconceptions on the subject.

Analysis in this thesis is related to branch of science. Qualitative study aims to understanding of the object, its quality, features and meanings as a whole. According to Aaltio (2014) collecting research material and analysing it is an iterative cycle. While collecting the material it was also evaluated and partially the final theoretical part developed at the same time with material collecting. First the material and observation

were simplified and then compared the theoretical part with the empirical findings to finally get the results presented in chapter 7.

CONTRIBUTION TO THE RESEARCH QUESTIONS

This chapter describes the used research methods and research strategies. It contributes the research by describing how the research was carried out to achieve answers to the research questions.

4. LITERATURE REVIEW

This chapter includes a literature review on learning, learning organizations, tacit knowledge management and process models. First three are connected to the second research question, how the tacit information, which is generated during the process, can be saved. Learning, organizational learning and knowledge management are tightly linked to each other. To create a system where tacit information from the process could be saved and reused in the organization knowledge management for tacit knowledge has to be studied. When tacit knowledge is transformed to explicit and saved to the use of the whole organization, organizational learning has occurred. And to understand organizational learning the basics of learning has to be studied.

Finally, to answer to first research question (what kind of information is generated in different phases of the new product process) and to find out where the tacit information is created and which part of it would be useful for the organization the process in scope has to be well known. To know this process better process models matrices are researched and used.

4.1 Learning theories

To be able to understand learning organizations we must first understand what is meant by learning. Learning is a wide concept which literature has been trying to define and create theories of. Illeris et al. (2009) present that learning itself consists of several complex processes which is why it is difficult to create an all-inclusive definition for it. This chapter introduces a few of the different theories of learning.

Hislop (2005) has studied a lot of different theories of learning and is saying that there is a lot of disagreement on what is learning and especially how it is present in organizations as it is described in next chapter. Hislop lists three mechanisms of learning that are applicable to most of the theories: formal training or education, learning via interventions in work processes and learning that is embedded in and emerges from day-to-day work activities. The first one is familiar from school and studies, the second one is basically learning from mistakes or other unconventional incidents and the last one we face when learning by doing. (Hislop 2005)

Most of the theories and definitions for learning found from literature rest upon experience. The most known of the theories is probably the Kolb's learning cycle which is presented in figure 7. In Kolb's theory learning is based on an experience which is then reflected and observed by the learner. The second phase creates a base for new concepts

and schemes which are then created or combined with old ones in third phase. In the last phase the previously created new theories and models are tested in practice which again creates new experiences. (Russ 1998)

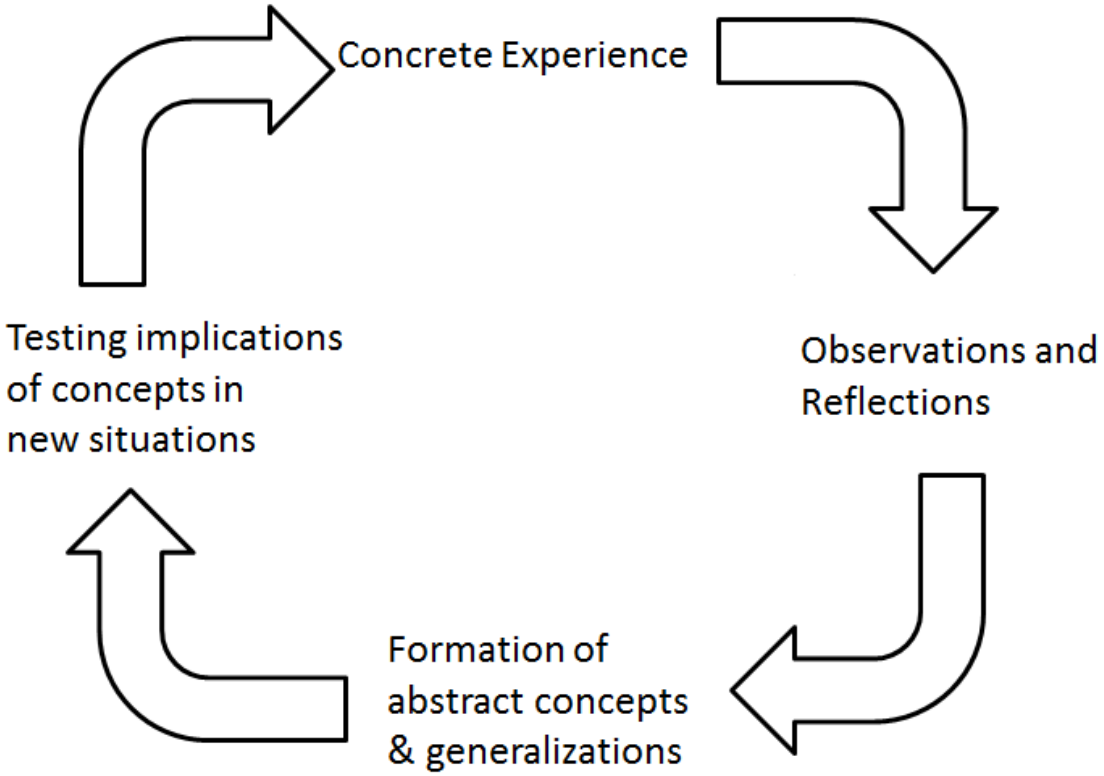


Figure 7. Kolb's Learning Cycle. Adapted from Russ (1998).

According to Illeris et al. (2009) the Kolb's learning cycle is too simple to be able to explain the complex process of learning. Russ (1998) has also criticized experience-based theories. He's opinion is that it's not necessarily good to learn everything through experience. Learning from others experience is very useful too. Learning can also be unconscious event when it's not leading to the observations and reflections phase, but learning has still happened. (Russ 1998)

For describing the process more comprehensively Illeris et al. have presented an updated version of Kolb's cycle: the Jarvis' model of learning (figure 8). In the model Jarvis wants to emphasize that the outcome of learning is always a changed person. The changed person can cause multiple consequences to its environment but not necessarily. According to Jarvis' model there first is a person who is influenced by a situation or experience. By evaluation, reasoning and reflecting, practice and experimentation, and memorisation the person is either changed or not. Not all situations or experiences lead to learning, so the person might as well stay unchanged, but if the learning occurs then also the person is changed in one way or the other. (Illeris et al. 2009)

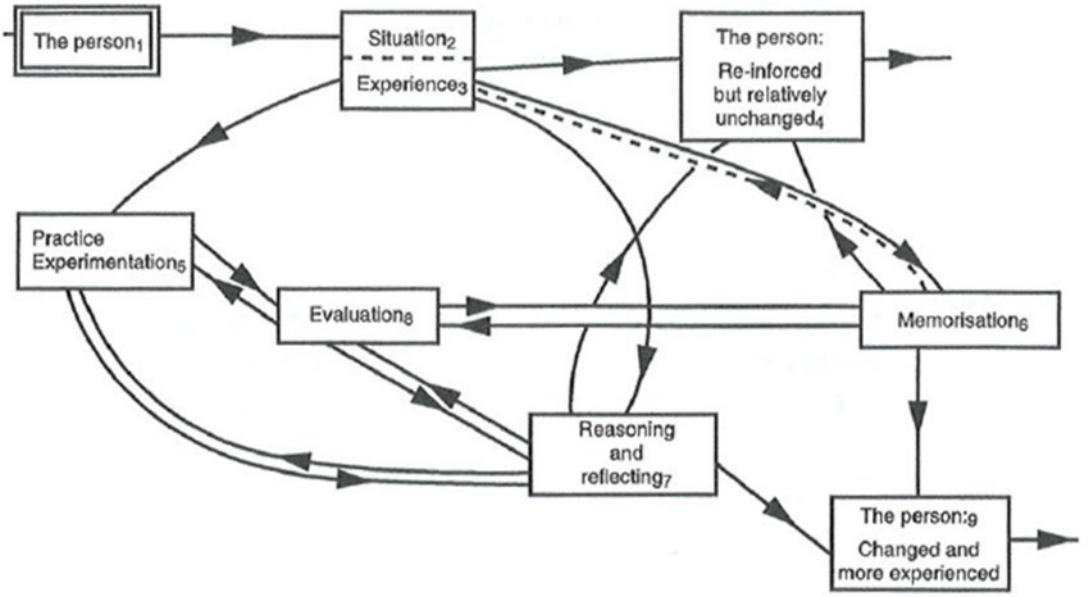


Figure 8. Jarvis' model of learning (Illeris et al. 2009)

Illeris et al. (2009) also emphasizes that in learning there are always two processes. One of which is usually forgotten in the concept of learning theories. First process is the interaction between the learner and the surrounding social, cultural and material environment. The second process starts internally, in the learner's mind. It is a psychological process where the stimulus from the first process is combined with existing knowledge. They present that there are four types of learning: cumulative, assimilative, accommodative and transformative. Cumulative learning creates a totally new field of knowledge. This type of learning is usually happening in the early years of a human beings' life. Assimilative learning links new information to existing knowledge to complement it. It is also the most common way of learning. Accommodative learning is quite close to assimilative, but in accommodative learning an old model or pattern must be broken down to link new information to it. Transformative learning is usually triggered by a major life event or crisis when there is no way back to the old way of thinking. Transformative learning leads to changes in personality. (Illeris et al. 2009)

Another a bit newer theory is Krumboltz's (2009) happenstance learning theory (HLT). The happenstance learning theory is based on that "human behaviour is the product of countless numbers of learning experiences made available by both planned and unplanned situations in which individuals find themselves". All the learning leads to new skills, interests, knowledge, beliefs, preferences, sensitivities, emotions and future actions. Every time an individual is conscious, learning is happening. Whether it is a small notice or a meaningful skill, all in all it is learning. As the name suggests all learning cannot be predicted or guided into certain direction, since there are so many agents af-

fecting to what an individual learns starting from genetics and environment to surrounding people and atmosphere. (Krumboltz 2009)

Laamanen (2012) has also a different view on learning. He defines it to be the *probability* of succeeding. The more often one succeeds in something the more he or she knows it. Virtainlahti (2009) defines learning to be a special skill or a knowledge that emerges in different situations and experiences where inner energy and motivation are key elements. Virtainlahti (2009) also presents Viitala's pyramid of learning (figure 9). The bottom part is the basic skills that are needed to develop the upper parts.

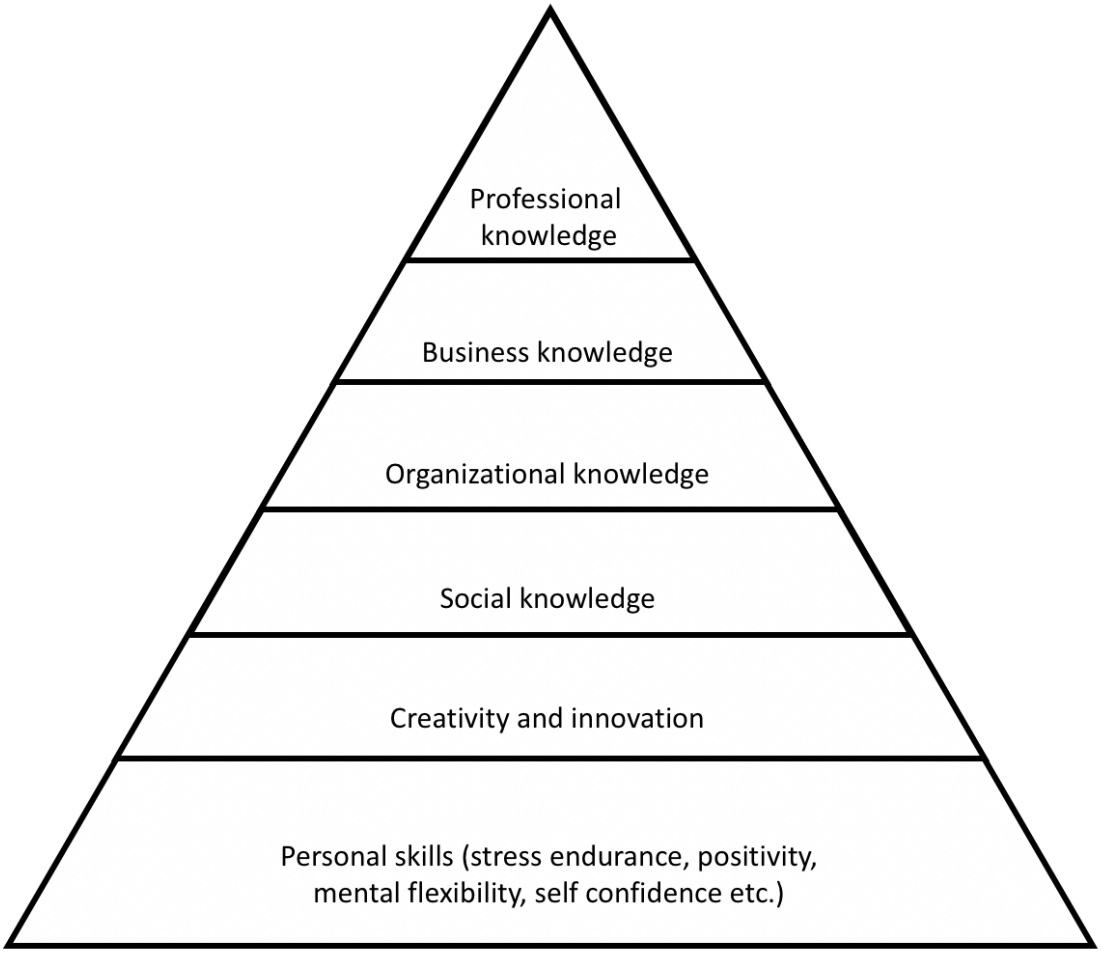


Figure 9. Viitala's learning pyramid, adapted from Virtainlahti (2009)

De Houwer et al. (2013) present three definitions to learning: functional, mechanistic and ontogenetic adaptation. Functional learning is the most common interpretation of learning and appears as change in behaviour. It has also been criticized for being too simplifying. Behaviour can change without learning too. Mechanistic learning creates change in organism which sometimes can lead to changes in behaviour but not necessarily. Even De Houwer et al. don't have an answer how can one tell if learning has occurred, how can changes in organisms be measured. Ontogenetic adaptation is a theory close to evolution theory. In evolution a species adapts to its environment over centu-

ries, but in ontogenetic adaptation learning an individual organism adapts to its environment during its own lifetime. (De Houwer et al. 2013)

Learning can also be defined as discovering defects and correcting them. In other words, learning can be achieved through correcting errors. A close theory for this definition is theory of single-loop and double-loop learning. The theoretical models are pictured in figure 10. Argyris (1999) states that majority of learning in organizations is happening in single-loop method where mistakes are corrected to reach the same level as previously. Single-loop learning is also called adaptive learning (Ahmed et al. 2002).

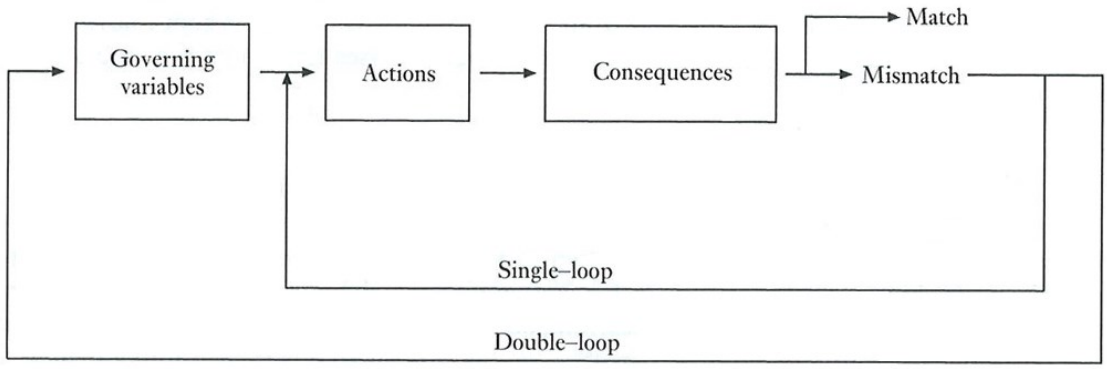


Figure 10. Single-loop and double-loop learning (Argyris 1999)

In double-loop or generative learning the current stage of the process is questioned and then improved. Double-loop learning focuses on bigger changes and not correcting the small variances. (Ahmed et al. 2002; Argyris 1999) Important factors for enabling double-loop learning are encouraging to experimentation and also submitting feedback from the ongoing experiments. (Ahmed et al. 2002) In addition to single-loop and double-loop learning there is deutero-learning where the learning methods are being questioned and the goal is to develop the learning process. (Lönnqvist et al. 2005)

Hislop (2005) has gathered a table of typologies of learning (table 2). On top of what already has been discussed in this chapter the table presents the levels of learning: individual, group level, organizational level and the largest scale inter-organizational learning. Crossan et al. (1995) has made the same categorizations. This thesis focuses especially on learning in organizations.

Table 2. Typologies of learning. Modified from Hislop (2005)

FRAMEWORKS	CONCEPTS/LEVELS	DESCRIPTION
Learning models	Cognitive	Learning as a change in intellectual concepts and frameworks (at individual or group level)
	Cultural	Change in inter-subjective, group based values, concepts or frameworks
	Behavioural/action based	Learning occurs primarily through action followed by a process of critical reflection
Learning types	Single-loop	Incremental chages within a coherent framework of theory
	Double-loop	Learning where existing theories/assumptations are questioned and reflected on
	Deutero	The highest level of learning which involves the process of learning and reflection itself being questioned
Learning levels	Individual	Changes in the behaviour or theories and concepts of an individual
	Group	Changes in group level, shared understandings or practices
	Organizational	Institutionalization at organizational level of changes in behaviour/theory
	Inter-organizational	Learning at supra-organizational level - for example within a network or sector

As stated in the beginning of this chapter there are many theories how learning occurs. Especially difficult it is to find a common opinion how we know learning has happened, how it shows. Common for all these theories is that it all starts with an external input, experience or stimulus. And result is like Russ (1998) puts it: learning is the process of creating knowledge.

4.2 Learning organization

If learning was not an easy term to define, learning organization is even more challenging. Many of the references emphasize the competitive advantage that learning organization brings compared to other companies in the same field of technology. For example, Marquardt (2003), Crossan et al. (1995), Lönnqvist et al. (2005), De Holan et al. (2004) and Virtainlahti (2009) have stated that if we learn faster than our competitors it is likely that we succeed better. Nowadays change in every sector is so fast, everything is available 24/7 and the world is closer than ever. To keep up with the pace organization has to be learning. Learning that happens in the whole company and beyond organizational levels is the best key to surviving and succeeding in the business. The importance of learning organization and knowledge management is widely known, but taking the theory into action is very challenging (Kirjavainen & Laakso-Manninen 2000)

There are two very opposite schools: the visionaries and the sceptics. Most of the researchers cited in this thesis belong to the visionaries' school. According to the visionaries learning organization is achievable and has benefits for both employees and em-

ployers. In the visionaries' view learning organization is flexible, adapting and that way brings competitive advantage. The sceptics on the on the other hand think that learning organization methodologies lead to emphasizing the power of the management and employees' exploitation. They criticize the way of management to be put in contradictory situation. Despite the learning organization's flat structure and self-orientation, the management still has the responsibility of the organization and it should be responsible to the management team and stakeholders or the company. Sceptics also state that in the literature on learning organizations power relations, conflicts and politics aren't considered. In recent literature the situation has gotten better though. They also claim that the theories of learning organizations don't consider human beings' feelings. Usually, learning something new forces us to let go of some of the existing habits which may cause for example anxiety, hostility or defensiveness. All in all, learning is including a lot of emotions that are rarely considered in the literature. (Hislop 2005)

Learning is bound to continuous improvement. The idea of continuous improvement is to make a change, learn from it and make new improvements according to what was learned previously. In ideal situation learning would be the by-product of working which means it would be continuous instead of learning before doing. Marquardt (2003) states that the ability to learn is more important than the knowledge itself.

According to Attewell (1992) an individual is learning when his/her experiences are transformed into understanding, skills or knowledge. Organizational learning is based on this individual's learning when the members of the organization are learning. Attewell (1992), Lönnqvist et al. (2005) and Hislop (2005) define organizational learning to have happened when individual's knowledge and skills are embedded to the processes of the organization. The knowledge and skills the organization has learned should be present in the organization even if the person originally learning the skill is no longer a member of the organization (Attewell 1992). Lönnqvist et al. (2005) and Hislop (2005) both make a difference between organizational learning and learning organization. In learning organization its individuals have possibility to develop and reach the results they aim to. The individuals also have common goals and environment that encourages experimentation and open dialogue. (Lönnqvist et al. 2005; Hislop 2005)

Crossan et al. (1995) has made lot of research on organizational learning and thinks that its definition depends on not how we define learning but how we define organization. Some researchers, like Lönnqvist et al. (2005), have stated that organization is a sum of its members. Then also organizational learning is upon the individuals learning. Other researchers think that organization is more than the sum of its members when also organizational learning is more group level learning than individual learning. One theory presents that biologically learning is possible only in individual's brain and so also organizational learning must be depending on individuals. (Crossan et al. 1995) Marquart (2003) brings out the opinion that organizational learning is more than the sum of the learning of its individuals and teams. Other researchers think that on top of individual

learning there is also group learning and the key in it is sharing information. According to others it can also be an extension of individual learning. When moving from individual learning to organizational learning one must consider also systems, working methods and structures of the organization. After all, Crossan et al. (1995) pose a question: are organizations really learning or are they just benefiting from knowledge sharing and individual learning. (Crossan et al. 1995)

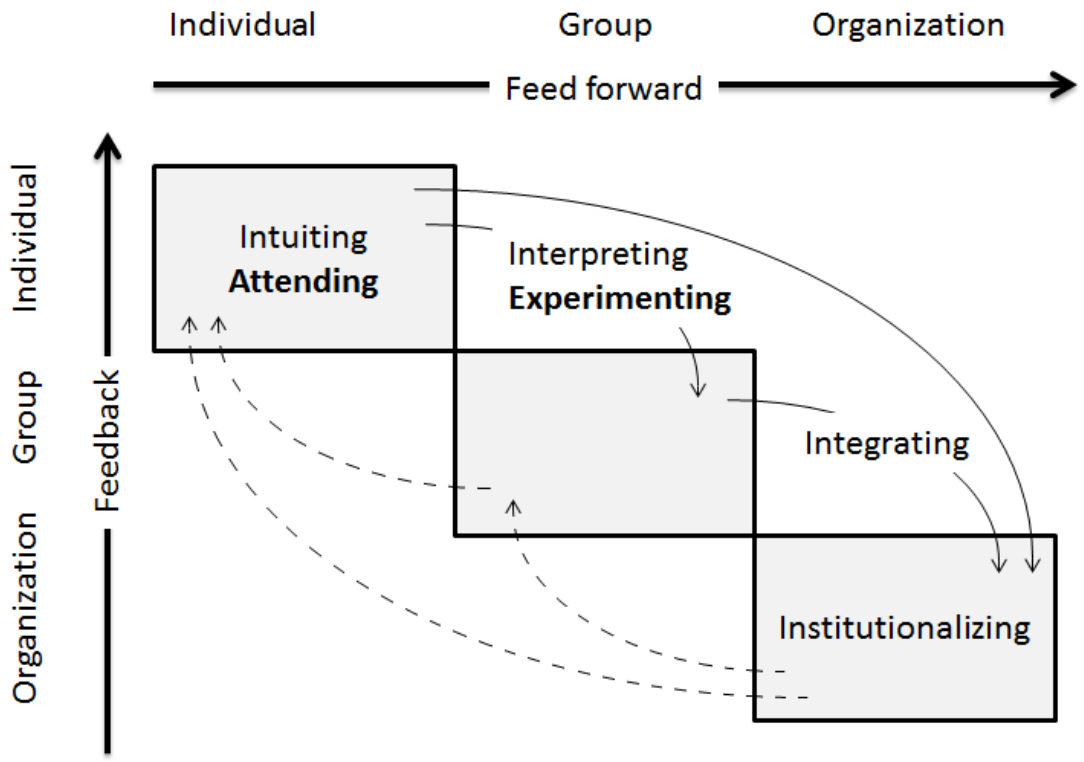


Figure 11. The modified Crossan et al. framework of organizational learning (Hislop 2005)

Crossan et al. (1995) presents the framework of organizational learning in figure 11. It is based on feedback and feed forward. It all starts from individual, but also group and organizational level learning is considered to happen. Actually Crossan et al. (1995) don't include learning. They rather use terms like intuiting, attending, interpreting, experimenting, integrating and institutionalizing. On individual level learning is present mostly by intuitive level or by attending to an activity. By interpreting and experimenting with current knowledge can learning be upgraded to group level and by integrating it into use it is on organizational level. Institutionalizing the new knowledge it is brought back to individual level.

Senge's (1994) definition of people in learning organizations is that people, who all the while learn how to learn together and widen their capacity to create the results they want to reach, have common goals that are over their individual goals and function together in many different ways, form a learning organization. (Ahmed et al. 2002) Mar-

quardt (2003) on the other hand approaches the definition from the organizational view. His theory is that organization is learning if it has the following five subsystems: learning, organization, people, knowledge and technology. The organization needs the all five features to succeed in learning.

Senge (1994) and Garvin (Harvard business review 1998) have also presented five features attached to learning organization: systems thinking, personal mastery, mental models, building shared vision and team learning. Systems thinking is a theory where the goal is to consider all the parts or functions of an organization because these parts need to function right to form a functioning whole. It is discussed more thoroughly in chapter 4.4.2. An error in one function effects on the other functions too. Personal mastery is the ability of an individual to be part of a functioning organization. To mention some of the abilities, patience and equity are one of those. Mental models lead the actions in the organizations. To achieve a learning organization the mental models behind the actions must be considered. Most of the mental models are unconscious, but they have huge effect on the human behaviour. Building shared vision, setting common goals brings the individuals in the organization closer to each other. The key is that the organization must have the common vision and goals, not just the management. Team learning is perhaps the most concrete action. It means developing the communication and dialogue between the team members. Senge (1994) compares dialogue to be comparable to thinking together. In addition, trust and the manager of the organization have a big role in succeeding. (Senge 1994) Inventing new knowledge should also be an automatic routine or behaviour in organization (Harvard business review 1998). According to Garvin (Harvard business review 1998) these are too abstract tasks.

Garvin in Harvard business review (1998) states that the key for learning organization is translating the knowledge into ways of behaving. Learning organization is not only good at creating of acquiring new knowledge, but it also has to apply the knowledge in practise. (Harvard business review 1998) Laamanen (2012) emphasizes commitment and participation so that the individual is the operator of the change, not just the target for change. Laamanen also refers to the PDCA model (Plan, Do, Check, and Act) and especially the “Act” part of it. His opinion is that learning happens when acting, examining results and researching how to proceed from there. (Laamanen 2012) Garvin lists the first two steps towards a learning organization: an atmosphere that encourages learning and creating learning forums (Harvard business review 1998).

Kirjavainen & Laakso-Manninen (2000) have listed very similar things as features of a learning organization (figure 12). On the left-hand column there are required features of the organization and on the right side there is what abilities it requires from the organization to achieve the left side goal.

Reacting to external environment	Sensitivity in customer interface
Common vision	Ability to aim together to future
Internal operations models and structures	Ability to change ways of action Open internal communication Change enabling structure
Individual's development	Constant development of know-how Job circulation
Team work	Learning together trough experience Trust and power to act
Management	Involving, engaging and delegating managing methods

Figure 12. The features of a learning organization (Kirjavainen & Laakso-Manninen 2000)

Laamanen (2012) has listed 14 principles or concrete actions that would promote organizational learning.

1. Management is studying and learning themselves and also teaching others.
2. Wide participation to planning, decision making, analyses and brainstorming.
3. Auditing or evaluating the skills, knowledge and learning.
4. Learning as a base of salary, to reward learning and encouraging to experimentations.
5. Developing IT systems and processes to support learning, self-orientation and taking responsibilities.
6. Setting challenging long-term goals, especially for learning.
7. Cross-organizational teams, learning teams, networks with other professionals.
8. Accepting and taking advantage of difference. Open minded and respecting atmosphere.
9. A lot of feedback, dialogue, mentoring, questioning and comparison.
10. Recognizing and creating learning situations actively, challenging projects and job circulation.
11. Study leaves, consulting from outside the home organization, teaching.
12. Continuous experimentation, encouraging to experimentation and calculating risk taking.
13. Educating methods for studying, learning, solving problems, innovating and creativity.

14. Modelling learning, learning maps, mind maps, training programs, benchmarking projects.

By following Laamanen's principles the organization should be getting towards the learning organization and the five successes that Garvin (Harvard business review 1998) lists: systematic problem solving, experimentation, learning from past experience, learning from others, transferring knowledge. Systematic problem solving should include scientific methods, rest upon data, not assumptions and use statistical tools. By experimentation is meant systematic searching and testing of new knowledge, learning by doing. Reviewing past successes and failures is a useful tool to learn from past experiences. But not all learning comes from reflection and self-analysis; learning from others is also a very important part of learning. For example, getting to know companies with very different field of business or benchmarking projects. Lastly, the key is not only to learn and gather knowledge but to transfer knowledge into use of other individuals. Some example tools to transfer knowledge are written, oral and visual reports, site visits, tours and personnel circulation, education and training, and standardization. (Harvard business review. One more effective tool is to actively experience. It is much more effective than having it described. 1998)

Kirjavainen & Laakso-Manninen (2000) present four tools to learning organization: IT and IT systems, phasing, increasing the efficiency of creative process and lastly removing obstacles and creating supportive structures. In IT systems the information is available to all and it is in unambiguous form. By phasing Kirjavainen & Laakso-Manninen (2000) mean four stages instead of a giant goal of organizational learning: get information, use information, learn new information and share information. With increasing the efficiency they refer to Nonaka's and Takeuchi's (1995) SECI-theory. There are four types of obstacles for organizational learning. Structural and systematic reasons are for example lack of communication forums or lack of co-operation management. The uniqueness of individual's own knowledge and inventions are an example of psychological and power political reasons. Missing common goals and common decision-making routines are managemental reasons. If learning the hard way is considered embarrassing the reason is in the organization's values. (Kirjavainen & Laakso-Manninen 2000)

Nonaka (Harvard business review 1998) describes four basic patterns when knowledge is created in organization. Tacit to tacit information happens between individuals, it happens during socialization where information is not brought to explicit at all. Opposite version is from explicit to explicit where two or more explicit information are combined and connected into a new one. Between tacit and explicit the information can go two ways: from tacit to explicit or from explicit to tacit. By articulation of tacit information, it can be transformed to explicit. The other way is more complicated. When an individual starts to broaden, extend and reframe the explicit information that he or she has the information becomes explicit. (Harvard business review 1998)

Both Kirjavainen & Laakso-Manninen (2000) and Virtainlahti (2009) refer to the SECI model by Nonaka & Takeuchi. Nonaka's and Takeuchi's (1995) well known SECI model describes the process of creating knowledge, but it is also very useful in describing the transformation of tacit knowledge into explicit. It consists of four modes of knowledge conversion between tacit and explicit knowledge: socialization, externalization, internalization and combination. The model is presented in figure 13.

Socialization is forwarding the tacit knowledge straight to tacit by sharing experiences, schemes of things or technical skills. The channel is interaction between experts and the essential part is sharing experiences. A good example is a novice learning from a master. In externalization the tacit knowledge is transformed into explicit knowledge, words, concepts or models through dialogue and shared observation. It is not an easy task to transform tacit knowledge into explicit, but usually parables and metaphors are best tools to illustrate. (Virtainlahti 2009)

Combination is used when the information is systematically transferred into IT systems. Then the already explicit knowledge is transformed into yet even more complicated unities of explicit knowledge. (Kirjavainen & Laakso-Manninen 2000) The information is exchanged via different documents, meetings, phone conversations and networks. The information is graded, combined, sorted, added and sorted. Internalization on the other hand is same kind of transformation but instead of IT systems it is transformed into tacit knowledge. This usually happens via learning processes which were discussed in chapter 4.1. Knowledge or information is transformed form explicit to tacit when a new way of action is taken into use. Virtainlahti (2009)

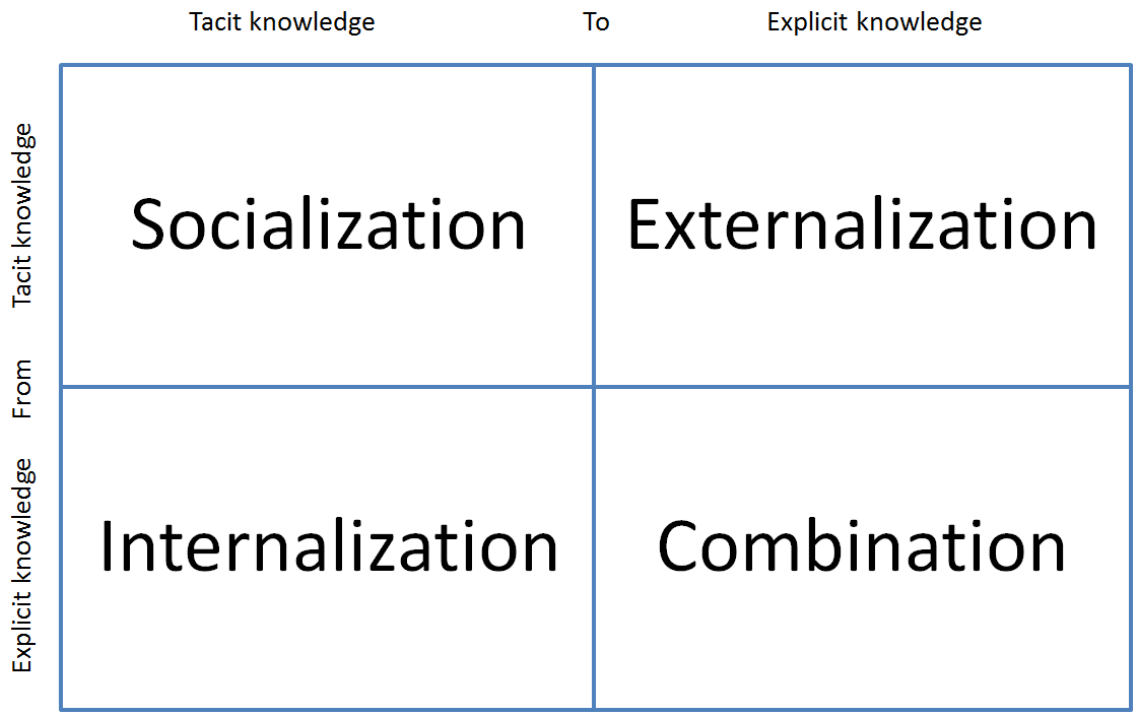


Figure 13. Four modes of knowledge conversion in SECI model (Nonaka & Takeuchi 1995)

The SECI model is often complemented with a spiral that is drawn in the middle of the figure. The spiral describes knowledge creation in organization where knowledge creation is continuous process and involves dynamic interaction between tacit and explicit knowledge. (Nonaka & Takeuchi 1995)

According to Kirjavainen & Laakso-Manninen (2000), Ahmed et al. (2002) and Senge (1994) learning needs also motivation from the individual. The individual has to create the knowledge by oneself from the information one gets from others. It requires intensive, continuous interaction with surrounding organization and its members. Ahmed (2002) states that "learning involves the action(s) of using existing insight or knowledge to produce new insight or knowledge".

How it is then possible to know whether learning has happened or not? Garvin (Harvard business review 1998) presents some tools to measure learning. For example, learning curves and experience curves are still functioning measures although being old. But those are not equivalent to learning organization since they only focus on one output at a time. Half-life curve also tells something about learning, but its problem is that it concentrates only on results. For measuring organizational learning Garvin suggests three methods that are overlapping each other. First stage is cognitive, how much is the organization exposed to new ideas and knowledge. It can be measured by measuring attitude, depth of understanding with interviews, surveys or questionnaires. The second stage is behavioural which means internalizing the cognitive parts which then causes changes in behaviour. At this stage doing should be measured by for example observa-

tion. Last stage is performance improvement. Behavioural changes lead to measurable improvements which then can be measured with half-life curves or similar. (Harvard business review 1998)

All in all, learning and learning organization are both very abstract concepts that are not so easy to define or measure. Harvard business review (1998) and Laamanen (2012) though gave good ideas for further research in the empirical part. As Crossan et al. (1995) states, if the goal is to have a learning organization we cannot think that it is only a sum of its members. This links also to systems thinking; the process or organization has to be seen as a whole and not just consider its individuals or parts of the process.

4.2.1 Organizational forgetting

Organizations should not only learn but forget too. According to Hislop (2005) organization cannot be learning organization if it's not capable of forgetting. Hislop (2005) also defines the organizational forgetting as "the reduction in an organization's memory that occurs when an organization becomes unable to do something it was previously able to do."

Hislop (2005) and De Holan et al. (2004) both present four types of forgetting presented in figure 14. Forgetting can either be accidental or intentional. Memory loss and failure to capture are accidental modes. Memory decay can happen when a key person is leaving the company, documentation is lost, or the knowledge is just not used enough to keep it in active memory. Failure to capture is the type that is most interesting in the scope of this thesis. It is the failure of transferring new knowledge from individual to the use of the whole organization. There are two steps to prevent this from happening: making the knowledge explicit and communicating. The last to types belong to the intentional mode: unlearning and avoiding bad habits. Unlearning is an intentional way of removing useless information. Usually when a new working method has become a routine the old ones are slowly unlearned. Learning new habits is as easy or difficult whether they were good habits or bad habits. Avoiding bad habits is important but not so easy to execute. Forgetting old routines and learning new is especially challenging in organizations that have long history and deep rooted routines. Key point is that the organization and its management have to be careful what it learns. All learning might not be positive. (De Holan et al. 2004; Hislop 2005)

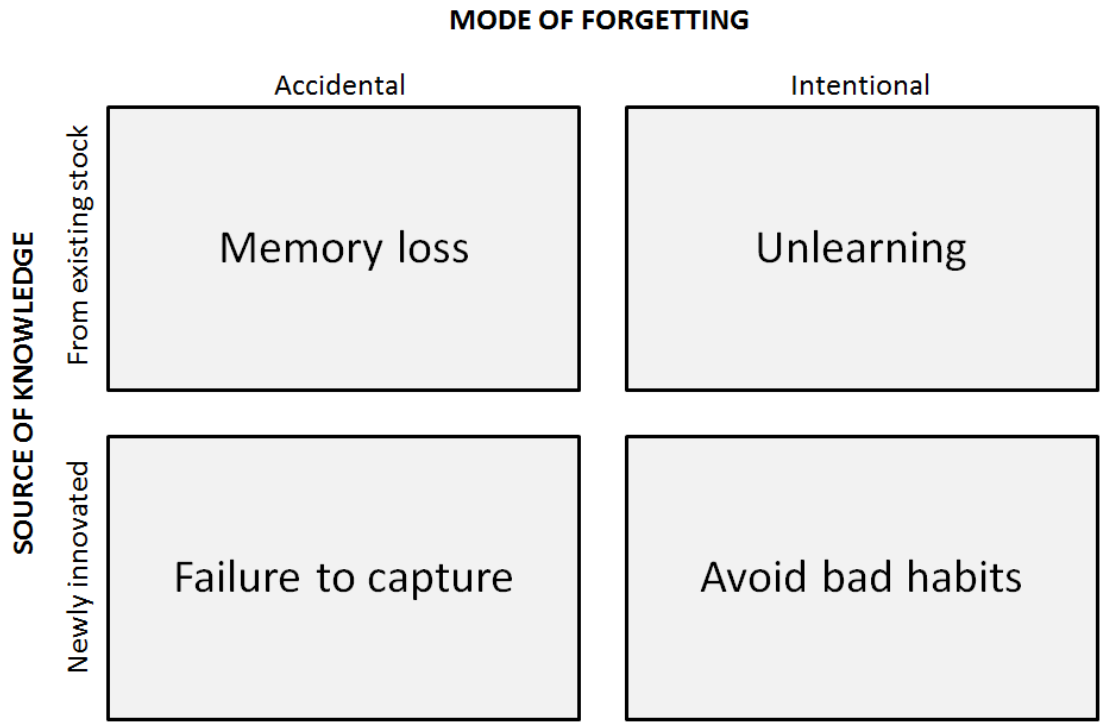


Figure 14. Typology of organizational forgetting (De Holan et al. 2004; Hislop 2005)

Hislop (2005) presents Lewin's theory how the organizational forgetting is happening. There are three steps, first of which is unfreezing, when the organization realizes that something has to change in the current system or process. Second step is when the planned changes and adjustments are made. This is called the process transition. Last step is freezing and then the new methods have become routines. (Hislop 2005)

Organizational forgetting can be either positive or negative. Sometimes it is possible to tell it only after years did it had a positive or negative effect. In general, accidental forgetting is usually negative or at least it is uncontrollable. Intentional forgetting on the other hand is usually done to reach a positive outcome. (De Holan et al. 2004; Hislop 2005)

There are several reasons and mechanisms for forgetting but either way, it is a noteworthy subject that should be considered seriously. It costs a lot of money to the company to lose capabilities. (De Holan et al. 2004)

4.3 Tacit knowledge management

Plato defines knowledge to be a well stated true belief. This is considered to be the classic definition of knowledge. (Virtainlahti 2009) Tacit knowledge on the other hand is knowledge that is based on individual's experiences; it is usually something we cannot explain why or how. (Koskinen et al. 2003) Usually even the term tacit knowledge is

familiar, but rare people can recognize the tacit information in their own work. (Virtainlahti 2009)

First, to define knowledge management or tacit knowledge management, knowledge must be defined. When discussing about knowledge there usually appears also words information and data. According to Greiner et al. (2017) and Ahmed et al. (2002) data is a set of numbers, facts and events. Data is meaningless numbers and letters without information. Information is interpret or grouped data that is placed into a context to get the potential value of the data. Knowledge on the other hand is more than that. Knowledge is processed information and when information is being processed it is combined with individual's own framework of experience, skills, intuition, ideas, judgements, interpretation, motivation and values. (Greiner et al. 2017, Ahmed et al. 2002, Lönnqvist et al. 2005)

The literature often divides knowledge into two main groups: tacit and explicit. Explicit information is easy to share since it is conceptual knowledge saved in documents or IT system. (King 2009, Ahmed et al. 2002, Greiner et al. 2017, Lönnqvist et al. 2005) It is said out loud, written into sentences or drawn. It has a universal character and it can be used in different contexts. Explicit parts of knowledge are information and data. (Järvenpää et al. 2016) According to Ahmed et al. (2002) most organizations have been concentrating mainly on explicit knowledge although they estimate that only 10% of all knowledge in organization is explicit. On the other hand, explicit information is much easier to manage than tacit one.

Tacit knowledge is usually perceived as an opposite of explicit knowledge, but they are in very close contact to each other and not separate fields of knowledge. There are also a lot of knowledge that is somewhere between tacit and explicit (Lönnqvist et al. 2005). Explicit knowledge is always based on tacit and tacit knowledge is needed to understand explicit knowledge. (Järvenpää et al. 2016, Greiner et al. 2017) Tacit knowledge is unspoken, feeling-based and personal. It is difficult to express or share verbally, written or with tools, but more commonly shared with demonstration. It is based on intuition, physical experiences, and skills, rule of thumbs, values and beliefs. (Ahmed et al. 2002, Lönnqvist et al. 2005, Järvenpää et al. 2016)

Lönnqvist et al. (2005) divides tacit knowledge into technical and cognitive. Technical knowledge is know-how, for example an artisan has tacit technical know-how how to bake perfect bread. Cognitive tacit knowledge is mental models, beliefs and observations that we take for granted. (Lönnqvist et al. 2005)

Besides classifying knowledge into tacit and explicit Kirjavainen & Laakso-Manninen (2000) present another way to group knowledge. They present knowledge in four groups by which question the knowledge is answering: what, how and why and lastly caring about the why knowledge. "What" type of knowledge is cognitive knowledge

that is mostly gathered from studies and education. “How” knowledge is more developed knowledge that is applied into practice. “Why” knowledge is comprehensive knowledge when the two previous are combined during the time. Last category is caring about the why knowledge which is most important in organizations. It is the desire to act and ability to independent action. The three first ones can be found from both individuals and organizations, but the fourth one is only in individuals and in the culture and atmosphere of an organization. (Kirjavainen & Laakso-Manninen 2000)

Awad & Ghaziri (2004) summarizes that the goal of saving tacit knowledge is to extract individual’s problem-solving knowledge to build a knowledge management system. As presented in research scope in chapter 2.2 King (2009) describes organizational learning to be the goal of knowledge management. Knowledge management itself is a tool or a policy of how knowledge is created, stored and used. When organizational learning focuses on the process, knowledge management’s focus is on content. (King 2009) Irani et al. (2009) on the other hand describes knowledge management and organizational learning to be similar but with different aims. To understand organizational learning one must understand knowledge management and its targets and processes. (King 2009) Third definition is by Hislop (2005) who presents knowledge management as an umbrella term to manage knowledge of the members of an organization.

Knowledge management is part of intellectual capital and the centre of knowledge management should always be people, not IT or communications technology. (Lönnqvist et al. 2005) According to Greiner et al. (2007) “knowledge management includes all the activities that utilize knowledge to accomplish the organizational objectives in order to face the environmental challenges and stay competitive in the market place”.

To save and share knowledge in explicit form it must be recognized first. (Lönnqvist et al. 2005, Virtainlahti 2009, Järvenpää et al. 2016) Knowledge can be recognized either by the owner of the knowledge or someone else. Besides recognizing the owner of the knowledge must have ability to communicate or transfer the knowledge forward. (Lönnqvist et al. 2005) To be understood correctly the sharer and the receiver should have at least partly the same point of view and knowledge of this world. (Järvenpää et al. 2016)

Companies have the urge to create processes to save tacit knowledge but very often there is no determination why it is done and what is the reason for it. A question should be asked, is the saved knowledge necessary? The project should start by recognizing and defining what is critical knowledge that should be saved. The next step is to think how the knowledge should be saved so that it will be useful. (Virtainlahti 2009, Järvenpää et al. 2016) Virtainlahti (2009) lists nine categories of what is critical knowledge:

- Knowledge tied to a certain occupation.
- What knowledge does each of the persons have?

- How are things handled?
- Who knows best a certain duty?
- Knowledge on the history of the company.
- Customer knowledge.
- Commercial practices in certain country.
- Knowledge on how to gather a team.
- How to approach a problem?

According to Virtainlahti (2009), after the recognition, sharing, developing and utilization of tacit knowledge, the process starts from valuing and respecting the tacit knowledge. It is important that the management respects the tacit knowledge but also that the employees would appreciate their knowledge. After having the culture or valuing the next step is to get to know other's work. Easiest way is to learn them is to do them. Also the organizational culture should not encourage to competing that leads to withholding knowledge. (Virtainlahti 2009) The most common reason for not sharing knowledge is trust. Knowledge is shared only to the persons that are trusted. Strong relationships between team members are in key role in succeeding in sharing knowledge. Also management's trust level has significant influence on the threshold of sharing knowledge. (Renzl 2005)

Kjaergaard describes the establishment of knowledge management as a three-stage process. The first stage is information process where new IT systems are created to make knowledge codifying and transferring possible. Second stage is organizational practice where the knowledge management is integrated into practice. Third and last stage is process integration where knowledge management is integrated as part of the process. (Kjærgaard & Kautz 2008)

Hansen et al. (1999) among others (Kirjavainen & Laakso-Manninen 2000, Hislop 2005) divides knowledge management into two fields: codification and personalization. First one is saving the knowledge usually into IT systems and the latter one is sharing the knowledge and communication. (Hansen et al. 1999, Kirjavainen & Laakso-Manninen 2000)

Problem with codification is that how to use the saved information efficiently. Does adding the knowledge into an IT system transform it automatically used? Codification usually works best in companies that produce standardized products. (Kirjavainen & Laakso-Manninen 2000) If codification is seen to be more than just saved information, it has a lot of potential. Awad & Ghaziri (2004) defines codification to be transforming existing knowledge into generally understandable and accessible from. Their opinion is that codification is essential for any knowledge transfer. Tools to codification are for example knowledge maps, decision tables, decision trees, frames, production rules and software agents. Knowledge maps can be used to create a map of current knowledge and knowledge gaps. Decision tables include first a list of conditions and second a list

of conclusions. Conditions are matched with the conclusions with if – then matrix. Decision trees are similar to decision tables. Decision trees are familiar from different kind of tests where one has to choose the path by current situation. Frames catalogue the knowledge with values. Production rules on the other hand are well known from software. They are conditional statements, mainly simple if – then sentences. Software agents are people that can create software and other ICT systems to have a platform for knowledge codification and to support knowledge transfer. (Awad & Ghaziri 2004)

Personalization is a humane solution. It requires first to understand the human and get him/her on the same side before moving to knowledge sharing. Personalization requires cooperation and communicational skills to succeed. It is rarely successful in cultures of strong competition. As mentioned by Renzl (2005) already, trust is a key to knowledge sharing and it is highlighted especially in personalization. A good cooperation is based on trust. The more controlled the flow of information is the slower and more formal the process is. In open and spontaneous organization the information flows freely in accordance with interests and needs. Personalization fits better to companies that do innovative, customer specified products.

All in all both codification and personalization are required to successful knowledge sharing. But according to Kirjavainen & Laakso-Manninen (2000) the emphasis cannot be equally on both. By controlling only hard information it is not possible to go far in knowledge management. Soft values like will, excitement and imagination have a strong influence on the success of knowledge management. (Kirjavainen & Laakso-Manninen 2000)

Knowledge management and sharing tacit knowledge can be supported by several actions. Ahmed et al. (2002) introduces Leonard-Barton's and Sensiper's three ways to exercise tacit knowledge:

- problem solving
- problem finding
- prediction and anticipation (how something works)

Virtainlahti (2009) also lists actions that support tacit knowledge sharing. Those are all gathered in figure 15.

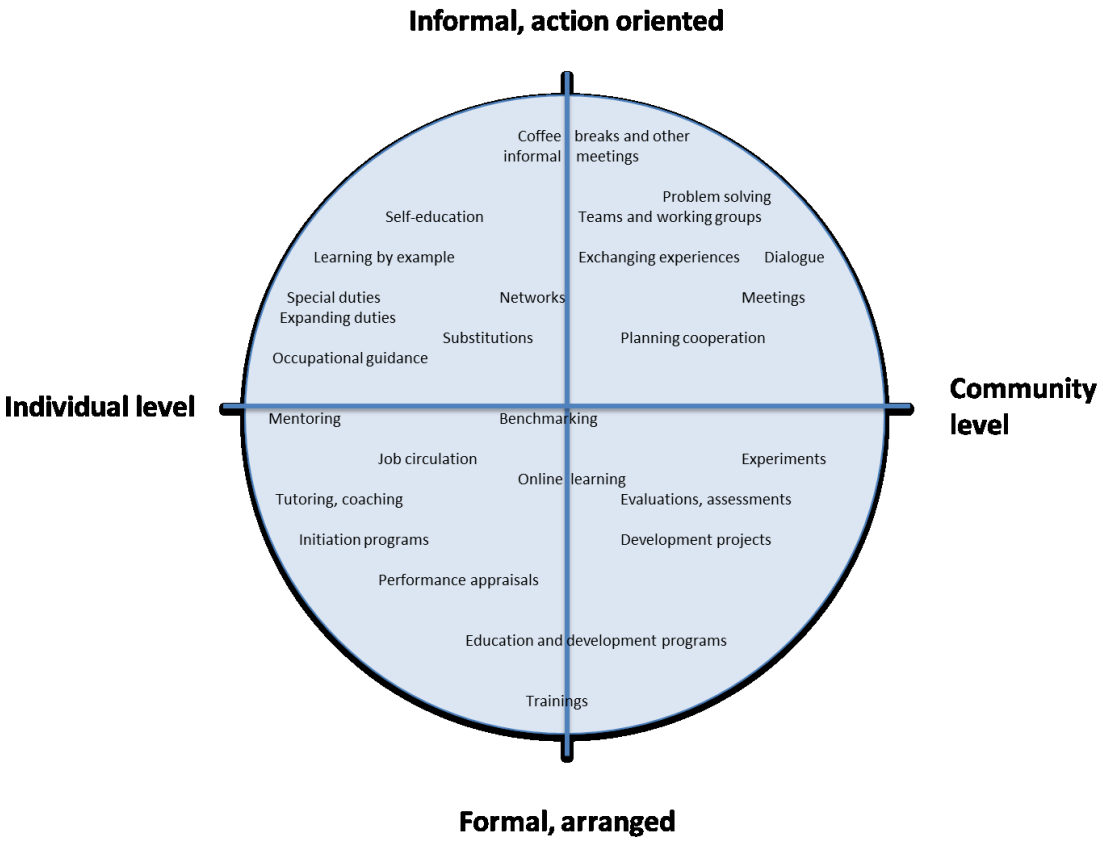


Figure 15. Actions supporting tacit knowledge sharing. Adapted from Virtainlahti (2009)

Cooperation forms that support sharing tacit knowledge (Virtainlahti 2009):

- teams and working groups
- mentoring
- substitutions
- networks
- exchanging experiences
- reflection

Virtainlahti (2009) also notes that other aspects affecting on sharing tacit knowledge are for example dialogue and work space arrangements. Developing the work should also support the sharing of tacit knowledge. Some examples of the developing methods are job circulation, expanding duties, enriching duties, projects and development projects, benchmarking and documentation of knowledge. Human resources organization can also have significantly effect to tacit knowledge sharing by recruiting, orientations, occupational guidance, education, performance appraisals. All in all feedback and communication are in the key role in developing know-how and knowledge. (Virtainlahti 2009)

Especially challenging situation in sharing knowledge is project-oriented jobs and processes. In projects there usually aren't existing mechanisms or working methods that

could be used to transfer the newly formed knowledge for other or upcoming projects. It is common that an individual moving from project to another is the only instance transferring the knowledge. (Järvenpää et al. 2016) Saving the information and knowledge should be taken into account already in the pre-phase of a project. (Disterer 2002) Disterer (2002) also recommends a so called lessons learned documentation and collecting all projects' data in one place to be accessible. Irani et al. (2009) made four conclusions on a case study made of a project work. Their opinion was that both managers and employees need training and education and those should be planned in strategy. If tacit issues aren't made explicit it effects negatively on project success. Communication should be a two way channel especially between management and organizations. Management should commit to bigger projects consistently. (Irani et al. 2009)

Literature gives a lot of examples how to start going into the direction of sufficient tacit knowledge management. Most of the advice is rather abstract and not so easy to measure. Nevertheless some measurements were found in the literature. According to Virtainlahti (2009) good management also measures the effects of made decisions and actions. The question is how to measure something as abstract as tacit knowledge?

To measure knowledge management Ahmed et al. (2002) suggest using PDCA cycle, COST model, EVA, the balanced scoreboard or intellectual capital. PDCA is a shortening from the four steps: Plan, Do, Check, Act. "Plan" step is capturing or creating knowledge, "Do" step is sharing the captured knowledge. "Check" step is measuring the effects of the shared knowledge and "Act" step is learning and improving. COST model helps organization to ask the right question, what is needed knowledge concerning customer, organization, suppliers and technology. By combining COST and PDCA a Knowledge Management Matrix is created which can be made from four different viewpoints: customer, organization, suppliers and technology. When operating expenses, taxes and capital charges are subtracted from net sales the result is economic value added (EVA). The balanced scoreboard is a multidimensional measurement system that has four perspectives: financial, customer, internal business processes and learning and growth. (Ahmed et al. 2002)

Virtainlahti (2009) also lists some variables to use when measuring knowledge management. The variables are presented in table 3. All the variables are related to learning and knowledge and hence are connected to tacit knowledge and knowledge management.

Table 3. Examples of variables and what can be analysed from the results. Adapted from Virtainlahti (2009)

Variable to measure	**What is actually measured**
Productivity	How much knowledge can be utilized in certain time period?
Work environment, atmosphere, employment duration, sick leaves	How well do people thrive at work and do they think it motivating?
Customer satisfaction	Satisfied personnel goes hand in hand with customer satisfaction
Motions and improvement suggestions	Describe personnel's readiness for changes and willingness to learn
Formal measures of knowledge, number of degrees	Describe the knowledge created during education

Recognizing tacit knowledge is affecting in the actions of an organization by changing the culture and valuing of knowledge. These can be considered by measuring contentment, atmosphere and working culture. It is also possible to evaluate the amount and quality of documented knowledge. Have ways of working, routines or special tips been described? Are the instructions fulfilling their function? Are the instructions easily accessible? One interesting variable to measure is motions compared to good quality motions. (Virtainlahti 2009)

Although Ahmed et al. (2002) gives multiple tools to measure knowledge management, neither of those does fully solve the challenge of knowledge management. Measurements can act great as a supporting tool for creating the right minded culture for knowledge management. Ahmed et al. (2002) also emphasize systematics and usability in knowledge codification. To be efficiently used the knowledge should be easy to find and not having to interpret. (Ahmed et al. 2002)

Essential and at the same time one of the most challenging aspects of knowledge management is sharing knowledge and especially sharing knowledge that is tacit. Lot of researchers argue that knowledge management is at least difficult if not impossible. (Hislop 2005)

Argyris (1999) presents his Model I which describes four aspects that people try to reach with their actions. Those four are achieving intended purpose, maximizing winning and minimizing losing, suppressing negative feelings and behaving according to what is considered traditional. These four are also the organizational defence routes that can slow or restrain knowledge management and knowledge sharing. (Argyris 1999)

The most common obstructionist is that the own knowledge and know-how is experienced to be a success factor or a competitive edge and therefor there aren't willingness to share information. There are though cases when this is sensible thinking. For example freelance entrepreneurs might not benefit from sharing their valuable tips. But often is thought that especially if there is a threat of notice that tacit knowledge is what makes the individual valuable for the company. Sadly, often is also the case that the tacit knowledge of an individual is recognized only after the person has left the company. After all innovative and knowledge sharing employees are a great resource for the organization and for the company. (Virtainlahti 2009)

This before mentioned knowledge withholding belongs to the immediate challenges. In sharing knowledge Virtainlahti (2009) divides the challenges into immediate and indirect. Indirect challenges might be rumours, it is thought that someone has information that they really don't have. Especially when there is a crisis or cooperation negotiations ongoing in the company, it is critical to inform the personnel whether there is something to inform about or not. This is the way to avoid the rumours that for example the employer has more information, but it is not told to the personnel. (Virtainlahti 2009) Järvenpää et al. instead divides challenges to social and technical. Those are presented in figure 16.

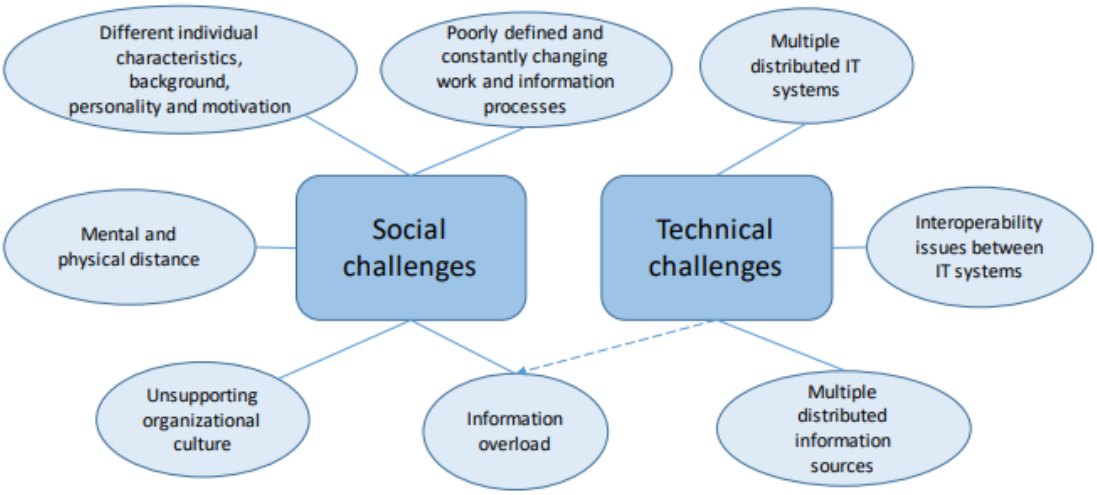


Figure 16. Main themes of identified knowledge and information management challenges (Järvenpää et al. 2016)

Social challenges can be for example human behaviour, individual characters and qualities, different backgrounds and vocabulary. Also the longer the distance between team members the more challenging it is to communicate the useful information. Technical challenges are usually connected to challenges with IT systems. Knowledge sharing will be challenging if there are several separate IT systems and those don't communicate with each other. (Järvenpää et al. 2016)

Transforming tacit knowledge to explicit and sharing knowledge has also some risks. It is difficult to protect intellectual capital. (Lönnqvist et al. 2005) There are also situations when it is not suggested to share tacit knowledge. For example if it tempts into a misuse of innovations and business ideas or as in the freelancer example personal know-how is the base of making one's living. Although if all misuses of knowledge are tried to be avoided then knowledge sharing is not possible. Also if tacit knowledge is outdated or false or it includes bias and prejudices it isn't useful to share or make explicit. (Virtainlahti 2009) As mentioned before recognizing the critical tacit knowledge is very important not to cause information overload by sharing all the knowledge available. (Kirjavainen & Laakso-Manninen 2000)

All in all there will be challenges in sharing knowledge no matter what. It is not possible to transform all the tacit information into explicit. All the knowledge whether it was tacit or explicit or something in between includes a tacit part that cannot be saved into IT systems or such. (Järvenpää et al. 2016)

Widen-Wulff (2007) describes it aptly that organizational knowledge tends to reside at the individual level. Although contrary, it is very descripting expression. Widen-Wulff lists five important influencers to information sharing motivation in organizations: culture, identity, networks, trust and timing. These are either enablers or barriers to information sharing.

Although it might be challenging, knowledge management has its benefits too. Investing in intellectual capital can have similar advances as investing in physical resources, such as increasing the know-how of the personnel, developing new products or increasing process functionality. (Lönnqvist et al. 2005) Tacit knowledge should be shared to be able to secure the quality, continuity and ability to act in an organization. Other benefits are bringing forward and developing duties, know-how and knowledge, share the best practices with everyone and exploit different knowledges. Sharing tacit knowledge improves the well-being of the members of the work community, which is based on that the one expert isn't burdened when the responsibility can be shared inside the organization. (Virtainlahti 2009)

Virtainlahti (2009) also proposes that the tacit knowledge and know-how created and developed at work isn't only employee's property. The employer should have a right to demand employees to share their knowledge to others. The employer is investing in per-

sonnel by education and initiation and thus should some of the investment return to the organization as shared knowledge. Sharing tacit knowledge makes it visible for the sharer itself too and that way it is easier to refine and develop further. (Virtainlahti 2009)

4.4 Process models

The English Oxford Dictionaries define the process model as ”a diagram or chart outlining the various steps involved in a particular process or set of processes.” As in six sigma theory process model usually means a mathematical function that models the process (Taghizadegan 2013). Also according to six sigma’s view “a cause-and-effect matrix relates the key inputs to the key outputs (customer requirements) using a process map and a cause-and-effect diagram as the primary sources of the input information. The key outputs are rated according to their importance, while the key inputs are scored in terms of their relationship to key outputs.” (Sokovic et al. 2005)

Process thinking has been in focus for the last decades. It all started from the rise of the Japanese quality philosophies like lean. (Martinsuo & Blomqvist 2010) Since then the amount of process models made has been increasing rapidly. (Aguilar-Savén 2004) Process models are needed to focus the resources on the value adding functions and to remove or reduce the non-value adding parts.

To be able to develop a successful, profitable system one must understand the process behind it. And to understand a process the tasks and features must be organized. The easiest way to manage it is to draw a process model. (Weber & Deubel 2003; Aguilar-Savén 2004) Besides understanding one must also have enough information on the process and on the other hand also on the reasons what creates profitable or successful process. (Martinsuo & Blomqvist 2010)

Processes are usually modelled to develop the process or to develop an IT system to support the process. (Aguilar-Savén 2004) Modelling a process is a tool for illustrating either the current process to see the possible faults and development needs or the target process after development actions. By drawing a process model the value adding actions and information and material flows can be recognized. (Martinsuo & Blomqvist 2010) Process models are also useful in decision making and to support the analysis. (Aguilar-Savén 2004) Aguilar-Savén (2004) divides process models into four categories:

- descriptive models for learning
- analytical models for decision making in process development actions and process design
- analytical models for decision making in process execution and control
- enactment support models for IT systems

The pros in modelling a process are for example visualizing the roles and responsibilities in the process. The drawn model also sets a standard for rules, actions and continuity. The biggest redeeming feature is the previously mentioned ability to illustrate the development needs. (Taghizadegan 2013) Despite the pros there are though some challenges in process models. It is quite common to do a process model without thinking what the reason for drawing it is. (Laamanen 2012) After defining the goal what is wanted to achieve with the process model it can still be difficult to find the suitable model, since there are so many to choose from. (Aguilar-Savén 2004)

Process modelling is a field with lots of research but it is lacking common rules. For example the used terminology is very different depending on the source. There isn't an agreement on the meanings of certain terms which easily leads to misunderstandings. (Aguilar-Savén 2004)

4.4.1 Process flow models

Many of the studies refer to flow when describing process models. Taghizadegan (2013) defines process model as a flow chart that visually describes the activities from input to output. A flow chart can express a series of steps, levels, actions or activities and the interaction between them. (Taghizadegan 2013) Giorgio (2015) on the other hand defines a process model as "a network of tasks interconnected by a data flow". Aguilar-Savén (2004) presents an example of one of the most common ways to draw a flow model in figure 17.

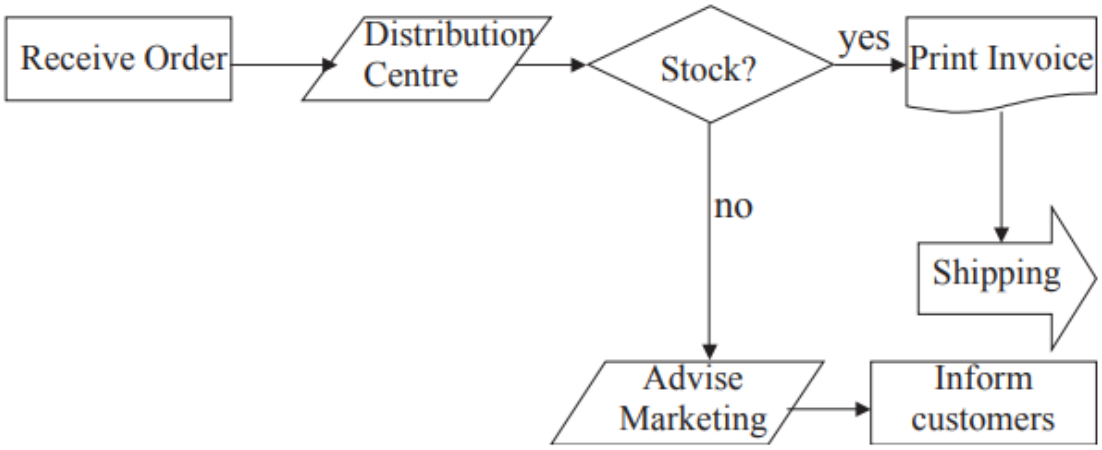


Figure 17. Example of a traditional flow chart. (Aguilar-Savén 2004)

Flow itself is quite undefined term. A flow chart can actually consist of any kind of flow that is draw into a shape of a graph or chart. Lehtonen et al. (2012) together with Koskela (2000) and Fujimoto (2007) present a different view on flow modelling. According to Fujimoto (2007) product development and production should be perceived as one process that would be modelled as a flow of knowledge no matter what form the knowledge has on different stages. This thesis doesn't cover product development, but the new product process can be perceived similar knowledge creation process as product development process. All in all flow through the product creation process is seen as a critical factor (Koskela 2000; Fujimoto 2007).

The starting point of the flow would be an intention, where it is understood what features the new product should possess. This intention guides the creation of new knowledge that can be presented in documents or 3D models. Later in the process the same intention and information is formed from material that together form the final product. Fujimoto (2007) defines the product development to be creation pf product information and production transfers this information into products. Customer at the end is the consumer of the information and also provides feedback to product development which again is creation of new information. (Fujimoto 2007; Lehtonen et al. 2012) The flow model helps to identify the steps of the process that are value adding to the end product. It also shows where information is created and how the design flow is formed. (Lehtonen et al. 2012)

Lehtonen et al. (2012) combines the theories of Koskela (2000) and Fujimoto (2007) and divides the information flows into four different flows. It is called PSI model and it is an acronym of Product Structure based Information flow. The four flows are introduced in figure 18. Knowledge flow describes the actions that are connected to the transformation of design information which are for example documents and prototypes. In work flow there are activities that are value adding and material flow includes the concrete raw materials and parts that are used to form the end product. Activities that are connected to the timing or inspection of the product belong to control flow. (Lehtonen et al. 2012)

FLOW	DESCRIPTION	RESULT
Knowledge	Transformation and move of design information	Documentation
Work	Work for value increase	Added value
Material	Raw materials and outsourced product parts	Added material
Control	Controlling events	Management of waiting and inspection

Figure 18. Elements in a flow model. (Lehtonen et al. 2012)

When modelling knowledge, data or information flow Lehtonen et al. (2012) and Fujimoto (2007) suggest considering four fields:

- Where the information emerges?
- Where is it used?
- Where it accumulates?
- What is its route to the end product?

Five principles to improve the process can be proved from the flow theory by Koskela (2000):

- Reduce lead time.
- Reduce variability.
- Simplify by minimizing.
- Increase flexibility.
- Increase transparency.

Common denominator for those is reducing the non-value-adding activities which are mentioned throughout many of the process modelling theories also mentioned in chapter 4.4. Although Fujimoto's (2007) theory concentrates on automotive industry and Koskela has studied civil engineering. Common thing for all the fields is knowledge crea-

tion and that point of view the theories can be applied to other industries too. (Lehtonen et al. 2012)

Different researches refer to knowledge flow with different terms. Basically can be generalized that all three, data flow, information flow and knowledge flow models refer to similar documents. As Fujimoto (2007) states that it is flow of knowledge no matter what form (information, data or knowledge) the knowledge has on certain stage. To ease the referring from this point forward the knowledge flow model is called data flow diagram (DFD).

DFD is a common tool in software or system development. It has been introduced in 1970's and is nowadays a common tool for information systems. (Millet & Nelson 2007) DFD describes the information or data that the previous part of the process has brought in and which the next part is going to use. (Sharp & McDermott 2008) In other words the process is visualized in the data point of view. (Aguilar-Savén 2004)

The purpose of a DFD is to illustrate the links between data collection, data transformation into information and finally decision. (Fountas et al. 2006) Fountas et al. also presents an example of data flow diagram in figure 19.

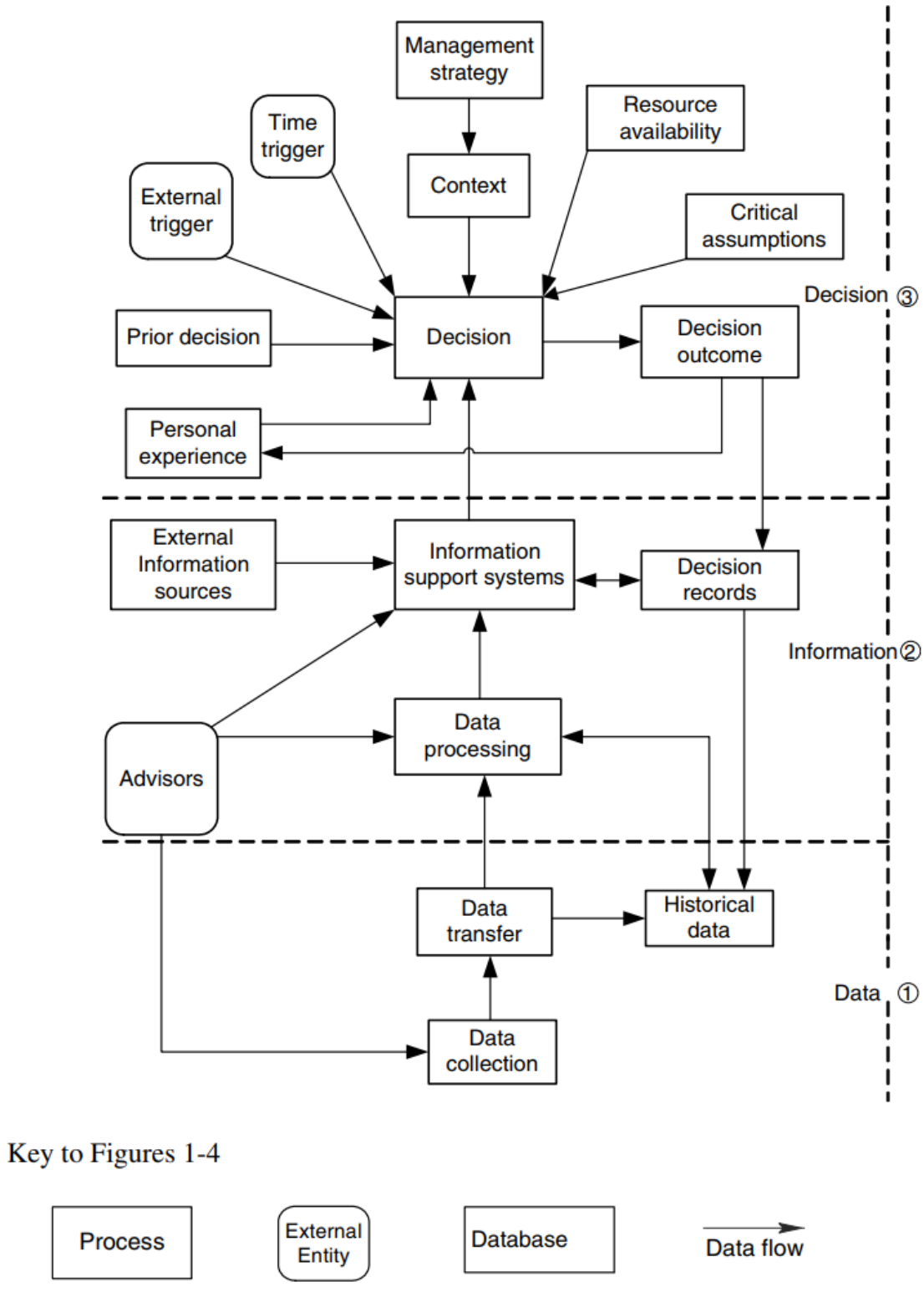


Figure 19. Generic data flow diagram of the decision-making in agriculture (Fountas et al. 2006)

The use of a DFD doesn't require much of initiation. It is rather easy to use even for a beginner. (Millet & Nelson 2007) Millet & Nelson (2007) also made interviews and according to them the DFD was found to be easy to understand and clear way of visualizing a process.

One big asset of a flow models is their flexibility. The model can be formed to fit the process and there are several ways to draw it. Aguilar-Savén (2004) has compared a flow chart and DFD by their features, strengths and weaknesses in table 4.

Table 4. Feature comparison of flow chart and data flow diagram. Adapted from Aguilar-Savén (2004).

		Technique	**Flow Chart**	**DFD**
		Description	Graphic representation	Descriptive diagrams for structured analysis
		Attributes	Flow of actions	Flow of data
		Characteristics	Not sub-layers Great details No overview	Explains logical level sub-layers
Strengths and Weaknesses	**User perspective**	**Strength**	Communication ability	Easy to understand
		Weakness	Can be too large	Only flow of data is shown
	Modeller perspective	**Strength**	Flexibility Quick Simple	Easy to verify and draw
		Weakness	No method available Different notations	

Downside of a DFD is that it only describes the data flow, but that is an obvious con and that should be considered when making the decision to use a DFD to model a process. DFD's and other flow diagrams also tend to grow and the result is often a very large chart. It is a good choice when a detailed description of a process is needed, but it is not that suitable for an overall view. (Aguilar-Savén 2004)

4.4.2 Systems thinking

Theories of Lehtonen et al. (2012), Koskela (2000) and Fujimoto (2007) have a lot in common with the Theory of Dispositions by Olesen (1992). A connection between the moments when a feature is decided and when it is visible in the product is called a disposition mechanism. Lehtonen et al. (2012) also refers to Hubka's theory of quality. That defines dispositional mechanism to be "where the quality decisions are made and what are the consequences of those later in the life cycle". To understand the disposition mechanism creates a fundamental on design rules and the mind-set of the designers. (Lehtonen et al. 2012)

Besides data flow, Olesen (1992) presents also the dispositions that together for systems thinking theory. Data describes the part of what happens and dispositions describe the

changes that a decision causes. Disposition transfers the parameters whereas data transfers the inputs. Another key thing in systems thinking is, as the name refers, systems. According to Olesen (1992) the system has to be thought as a whole, not just concentrating on smaller parts of it. A decision concerning one part will also effect on the other parts. That means that a system developer has to consider other function's dispositions when developing only one function inside a system. (Olesen 1992) Senge (1994) describes it well: you can't divide your elephant in half. Senge also warns about organizational gridlock. An organizational gridlock happens when all the organizations are part-optimizing their own functions. The optimum for the whole systems is not equal to the optimum of its parts. (Senge 1994)

Superficially the systems thinking theory and process modelling are somewhat similar so they are also easily mixed together. Process model visualizes consecutive activities of knowledge, work, material or control that can be described with verbs, actions or steps and there is an arrow to point the direction of flow. A change in one part of a process model is not necessarily affecting to the other parts. In systems thinking the labels are variables, nouns or sentences, not functions or actions and change in one part effects on the whole system. Arrows in systems thinking visualize causality, not necessarily the order of the events. Process model is a static illustration whereas systems thinking describe the dynamic interrelationships. (Senge 1994)

CONTRIBUTION TO THE RESEARCH QUESTIONS

Learning theories and learning organization theory in chapters 4.1 and 4.2 by studying the saving of tacit information via learning organizations point of view. Chapter 4.3 contributes to the research questions by studying how tacit information can be saved and giving examples from literature. Chapter 4.4 is presenting process models and studying from the literature how can the process models be utilized to save tacit information which in other words contributes to the third sub-question.

5. COMPANY INTRODUCTION

This thesis is made in co-operation with SSAB Europe Oy. In this chapter a short introduction of the company, its history, colour coated products, product planning organization and new product process is presented.

5.1 Company and organization introduction

SSAB is a Nordic and US based global steel company which has over 15 000 employees in 50 countries. SSAB's history of making steel starts in 1878 and nowadays the annual production capacity of steel is 8,8 million metric tonnes. (SSAB B 2017) After the merge with Rautaruukki Oyj in 2014 SSAB became the leading steel company in the Nordic countries. (SSAB C) SSAB divides into five divisions: SSAB Special Steels, SSAB Europe, SSAB Americas, Tibnor, and Ruukki Construction of which SSAB Europe is concentrated on high quality strip, plate and tube products. Colour coated products are one part of SSAB Europe's product portfolio. (SSAB B 2017)

Colour coated products are manufactured on two lines in Finland: Hämeenlinna and Kankaanpää and in Finspång, Sweden. SSAB's colour coated products are painted on steel grades from 120 to 650 MPA (yield) and 0.40 mm to 2.0 mm thickness, up to 1500 mm width. The wide colour range of colour coated products has patented Bio-based Technology (BT) which includes high content of Swedish rapeseed oil instead of fossil-based oils. (SSAB B 2017)

The fusion caused that the main product planning responsibilities of the colour coated products were centralized to Hämeenlinna, Finland, but also many smaller parts of the responsibilities were decentralized to other organizations like production, technical customer service (TCS) and sales. Product planning is a three-person organization which is controlling the product information in different data systems and is also a link between product manager, product development, TCS and production. Product planning's main responsibilities are: (SSAB D 2017)

- responsible for product specifications
- owner of the colour matching process
- paint supplier changes
- keeping the product information up-to-date in the data systems
- new colour testing
- taking care of colour standards
- environmental inquiries

- certificates together with the quality department
- updating the production program

Of all the responsibilities the new product process was chosen to be the object of this study since it was most affected by the merger and since it creates major of the daily workload in product planning. Several requests or questions about new products are emailed every day. Approximately 15 of the requests lead to colour matching monthly. If counted by the organizations involved into the process, new colour process is definitely the widest of product planning's processes. At the moment the new product process is yet a bit obscure. The two former companies, SSAB and Rautaruukki, had a very different way of handling new product requests and now those ways are compressed into one way of working. At the moment an overall view of actions and responsibilities is missing.

5.2 New product process

From product planning point of view the process starts from the request to produce a new product. The process is considered finished when the data systems have the required information to enter an order to the system and produce the new product. In general the requests can be divided into two main groups: new colour requests and new products requests. New colour requests are the most common ones. New product inquiries can include everything between small adjustments to film thickness to totally new coating.

When it comes to a totally new coating it a product development project that follows the Cooper's stage-gate model. For these kinds of larger projects a so called PCP tool has been developed. PCP stands for product commercialization process and it is presented in the next chapter. Basically there can be recognized two main processes: PCP and production process. PCP's goal is to lead to production process. The new product process can be seen as a sub-process of PCP or happening in between of PCP and production process.

The state of the new product process in 2016 is presented in figure 20. That is the latest process model that has been done of that process, but since then some minor changes have been done.

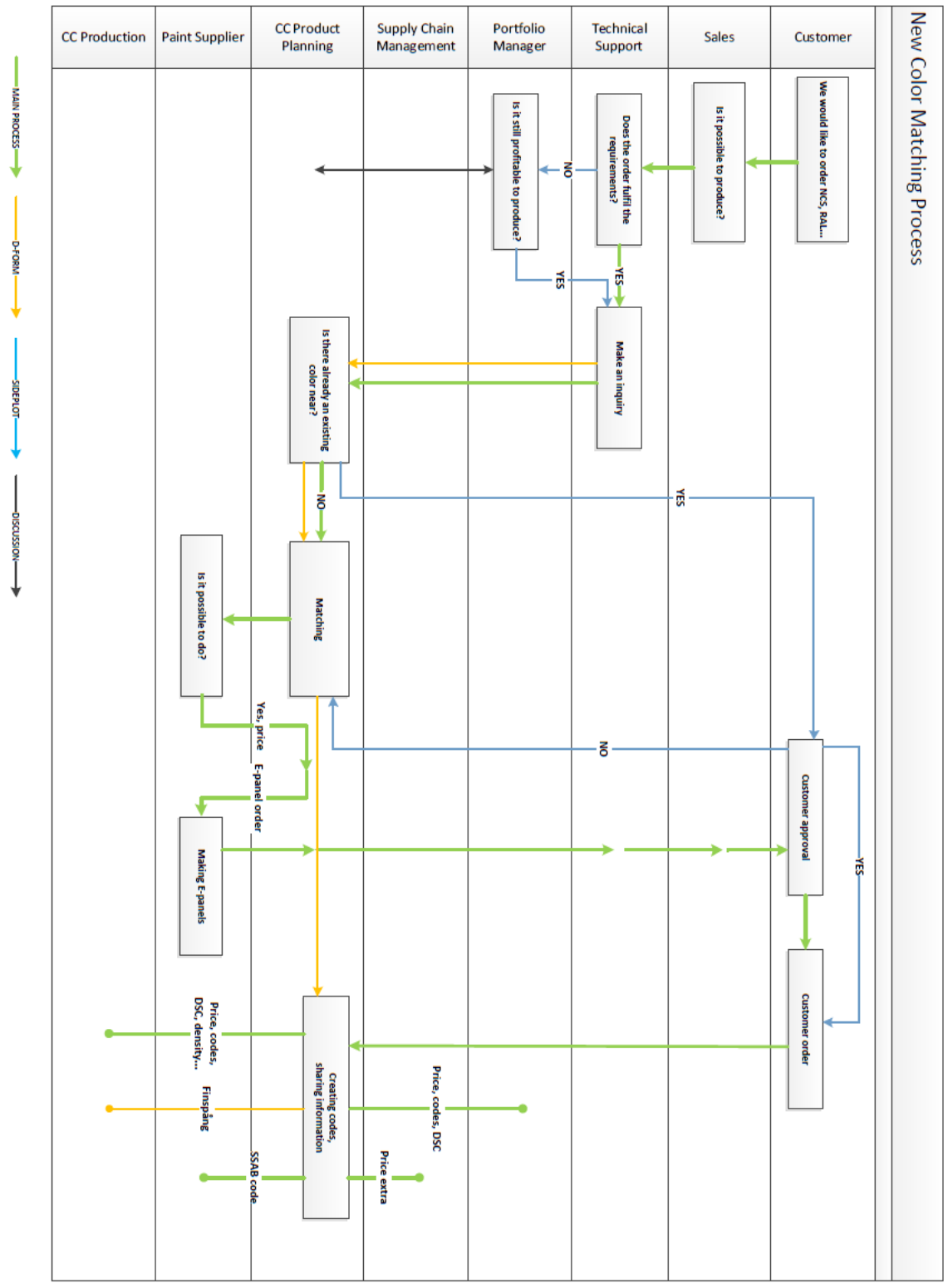


Figure 20: Process chart of new product process made in 2016.

Basically there are three phases in the phases in the process: evaluation, paint supplier cooperation and IT system updates. In the first phase, depending on the case, either TCS, product planning or product management is defining whether the product is profitable and feasible to manufacture. The next step is to define the final product price and get samples from the paint supplier for customer acceptance. If the customer accepts the

product then codes are created and IT systems updated for production to be able to run the product.

5.2.1 Product commercialization process

Product commercialization process (PCP) is a newly launched process that SSAB uses when commercializing new products. Its goal is to make the commercialization more efficient than previously. (SSAB E 2017)

The process has been designed so that all the organizations participating in the process have as comprehensive initial data as possible from the beginning of the process. PCP brings together all the different tasks that different organizations are executing and that way increases the transparency of the process to all its participants. PCP follows the Cooper's stage-gate model and it includes checklists for different stages from business idea to launch and commercial product. It also creates the basic elements for the new product process. PCP forms the frame inside which the new product process can act. Product management organization is the leader of the product commercialization process. (SSAB E 2017)

5.3 Challenges in the process' present state

The starting point of this thesis was to study the new product process since it was felt to be quite complicated. It seemed that a clear vision of the whole process was missing. Also to develop the process, the process must be fully understood first.

Apart from getting a full picture of the process some other issues were also raised during the workshops. Most common challenge that came out in several workshops was the visibility of the process. For example sales and production find it hard to follow what is the status of the process. Customers quite often ask for an update on the colour matching or product modification process. Product planning informs the sales via email when there is something to inform, but for sales or TCS it is hard to keep up where each of the processes is going at that point. Sometimes the process is experienced to be so challenging that the inquiry is neglected by the sales.

Before the merge a so called APQP program was in use at old SSAB. Every person involved into the specific new product process had access to it and could have seen the status of the process and comments from other organizations regarding the decisions made during the process. That way, also production was able to see what kind of products there are in the process and probably soon in production. Although the information is not crucial to production line it helps to create transparency and openness that create trust and connects the organization more tightly to the process. A demand for a common meeting was noted too. For example 2-4 times annually arranged meeting with all the

organizations involved in colour coating could handle for example claims, quality issues and development projects.

The process transparency is experienced as a challenge also in product planning. As mentioned in previous chapter product planning should be the organization to control the process and take care that all the information goes from the inquiry all the way to the production. On the other hand production planning doesn't have access to many of the IT systems that are used to control the process. In that way it is challenging to make sure that every product and every code is as it should be.

Another challenge that was brought up was the pricing. Product planning is the organization which determines the colour extra for a new colour, but the frame for the pricing is agreed in SCM and sales defines the final price that is invoiced from the customer. In short the price information goes very different route than the rest of the process and it was found to be inconvenient. Customers and sales also make quite a lot of price inquiries to delivery support which doesn't have the price information to give.

The speed of the process was also discussed. A lot of customers expect to have the samples of the inquired colour right away. The colour of a product is quite sensitive thing. The colour is needed to be as close as possible to the customer sample. On top of that the surrounding lighting affects the visual colour considerably. For those reasons the samples are painted in laboratories and physical samples are sent to customers for acceptance. For examples photos of the samples or "electronical" samples are sometimes required, but they don't necessarily give the right impression of the colour.

Product planning is experiencing the substitution or initiation of a new person the most challenging part of tacit knowledge management. Current way of working keeps the technical data of new product process iterations in safe, but the reasons for certain decisions are not saved. Those can be found in the email of the person in charge of that process iteration. The organization is lacking half of the historic data due to the merge. After closing the product planning duties from Sweden practically all the knowledge of the personnel were lost. As mentioned in instruction in chapter 1, also at that time the responsibility to do the information transfer and learning the other organization's duties was pointed to the employee level. Some files and folders of the former organization are available, but on top of the language barrier the current product planning organization doesn't know how the information in the folders and files has been used. For example history of different products and their evolution is unknown. Especially if the product name has changed it has been very challenging to figure out which product is in question. Also the results of long term testing and research results would be very interesting and useful information to have. All in all the ways of action and the practices were the most missed parts.

The current state of handling knowledge in product planning organization is getting better but there are fields for improvement too. All the files are collected in common location and the process is ongoing to translate all of them in English. One thing that rose up was the contact information. A list of certain responsible persons has been updated, but it is not all-inclusive. As discussed in the workshop, there could be use for a listing of persons that can be consulted in certain situations. For example people that have been working at the product planning previously or that have same other important information. However, the main challenge was the experience, how situations have been handled previously. Usually the matters that would need consultation of a senior employee are special occasions and silent agreements that are really hard to save in a file.

In conclusion it can be summarised that there were two major challenges in the process: transparency to organizations and keeping the decision making reasons available.

CONTRIBUTION TO THE RESEARCH QUESTIONS

This chapter contributes to the first research question by revealing the background and current state of the process.

6. DEVELOPING THE NEW PRODUCT PROCESS

The practical goal of this thesis was to find out the critical tacit information that is formed in new product process by creating a process model that has been contributed by engaged organizations. Second goal was to give a development proposal for developing the new product process. A present state analysis was made to the process via workshops. Some problems and challenges, that the parties of the process inquired to be changed, were recognized. On top of that a data flow diagram was formed in the workshops to help with figuring out the present state and to find out targets for development and especially tacit knowledge.

The next chapter presents the created DFD and analyses it. Also the literature review is utilized to find out the possible targets of development and critical tacit knowledge. Chapter 6.2 introduces the development suggestions for the new product process made considering the analysis results in chapter 6.1.

6.1 Data flow diagram

The theoretical research in previous chapters has presented different kind of flows and flow models. The flow model presented by Fujimoto (2007) and Lehtonen et al. (2012) has been utilized in this practical part and based on that, a DFD has been created. As Laamanen (2012) presents, it is quite common to do a process model without thinking what the reason for drawing it is. DFD was chosen since it supports the need to have the information, organizations and IT systems involved to be studied.

At the moment the company doesn't have a clear solution on how to manage knowledge. Partly the knowledge is employees' tacit knowledge and partly it is scattered in many different IT systems. Also the accessibility into some of the systems is limited. Before suggesting any tools or solutions for knowledge management it is important to identify what kind of information is created in the process and how it is utilized. As Lönnqvist et al. (2005), Virtainlahti (2009) and Järvenpää et al. (2016) write it, to save and share knowledge in explicit form it must be recognized first. This is also the reason for drawing the DFD.

When modelling knowledge, data and information flow four fields were considered after Lehtonen et al. (2012) and Fujimoto's (2007) suggest:

- Where the information emerges?
- Where is it used?

- Where it accumulates?
- What is its route to the end product?

Chapter 3.2 described the workshop working, participants and DFD creation in general outline. The workshops were arranged organization by organization to be able to concentrate on one smaller field at a time. The workshops were started off by going through the overall responsibilities of the participants and their organizations. After that it was time to concentrate on the new product process and the role of the organization revised. At the same time a list of needed information was gathered. The aim was to get a list of information that the organization in question needs at minimum to accomplish their own role in the process.

Next the question list of Lehtonen et al. (2012) and Fujimoto (2007) were gone through; especially answers for the first and third one were generated. The second question was already answered in the first phase of the workshop. The answer for the last question would be formed when all the workshops were done. When all the organizations have been gone through we should have a path of certain information from creation to the end product.

The finalized DFD was sent to participating organizations to be accepted and commented. The purpose was that the participants could go through also what other organizations had listed on their responsibility. Comments were mainly positive. Only couple of minor particularizations were made.

Two versions of the final DFD were made. The actual DFD concentrates on depicting only the data flows and its sources. From that model a wider chart was drawn to support the development needs. That model includes both work flow and data flow. Part of the finalized DFD is presented in figure 21 and the full DFD can be found in appendix A. Figure 24 describes the most used symbols in process models. The same logic has been used when drawing the data and work flow diagram, part of which can be found in figure 25. The full data and work flow diagram is presented in appendix B.

PRODUCT SERVICE	PRODUCT PLANNING	PRODUCTION PLANNING	PAINT SUPPLIER	PRODUCTION: QUALITY TECHNICIANS / ENGINEERS	PRODUCT MANAGE MENT	PRODUCT DEVELOP MENT	PROCESS DEVELOP MENT	MARKETING	NEEDED DATA	IT SYSTEM FIN	IT SYSTEM SWE
	x		x						Application / Wanted properties / Coating	email --> excel: D-form	email --> excel: D-form
	x		x						Gloss	email --> excel: D-form	email --> excel: D-form
	x		x						Colour reference	email --> excel: D-form	email --> excel: D-form
	x		x						Annual tons / m2	email --> excel: D-form	email --> excel: D-form
x	x								Steel/substrate, width and thickness, tolerances	email --> excel: D-form	email --> excel: D-form
	x								Protective film need	email --> excel: D-form	email --> excel: D-form
	x								Customer information / contact details	email --> excel: D-form	email --> excel: D-form
	x								Possibility to do the product	email --> excel: D-form	email --> excel: D-form
									Status of the process	email	email
	x								Colour matching criteria	email	email
	x		x						Archiving number: D-number of ECI case number	email --> excel: D-form	email --> excel: D-form
	x	x		x					Tolerances / Hold limits	IMS	MAS + Spec Admin
	x	x		x					Paints in use	IMS	MAS + Paint Admin
	x	x		x					Layers, painting order	IMS	MAS
	x								Production line	IMS	MAS + SAP
x									Suitable back coats	-	email --> SAP + MAS
x									MS number	-	email --> SAP
		x	x	x					Film thicknesses	IMS (+ email)	MAS + Paint Admin (+ email)
									Customer feedback	email	email
		x							Chosen suppliers	IMS	MAS + Paint Admin
	x	x							Paint price, DSC%, density	email --> excel: D-form	email --> excel: D-form

Figure 21. Part of the finalized DFD

IT SYSTEM FIN	IT SYSTEM SWE
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email --> excel: D-form	email --> excel: D-form
email	email
email	email
email --> excel: D-form	email --> excel: D-form
excel	excel
IMS	MAS + Spec Admin
IMS	MAS + Paint Admin
IMS	MAS
IMS	MAS + SAP
-	email --> SAP + MAS
-	email --> SAP
IMS (+ email)	MAS + Paint Admin (+ email)
email	email
IMS	MAS + Paint Admin
email --> excel: D-form	email --> excel: D-form
email --> Sales Configurator --> SAP (by MDM team)	email --> Sales Configurator --> SAP (by MDM team)
email + Sales Configurator	email + Sales Configurator
email	email
email	email
-	-
email --> excel: D-form	email --> excel: D-form
Remaster + Sales Configurator	Remaster + Sales Configurator
email --> IMS	email --> SAP
Lotus Notes	email --> SAP
IMS	email --> SAP
IMS (+ email)	email --> MAS + SAP
IMS --> Arttu --> SAP	MAS + Paint Admin
IMS	MAS + Paint Admin
IMS	Paint Admin
IMS	email --> SAP + Paint Admin
IMS	email --> SAP
IMS	Spec Admin
iColor	Colibri
IMS	-
IMS	-
IMS / Lotus Notes	email --> MAS + SAP
email --> IMS	email --> SAP
excel: PISU	MAS
email	email
email --> IMS	MAS
Chemsoft	Chemsoft
email	email
email --> IMS	-
IMS	MAS --> TVB
IMS	TVB
Lotus Notes	APH

Figure 22. IT systems used for information transfer in new product process. The ones including email are highlighted.

On the right side of the DFD a list of all the needed information was gathered. They are in that order they first appear during an iteration of the new product process. The headers of the columns are the organizations involved in the process and below them are the information needs marked with x. The sources of information are colour coded. The darkest tone is the original source organization that brings the certain information into the process. The information transfers from darker to lighter tones eventually ending to the organizations that need it. On the two columns in the very right there are IT systems that the information uses to move in the process.

One thing that emerged was the amount of email traffic during the process. A lot of information is transferred via email which means that is in the archives of two individuals instead of somewhere accessible. Figure 22 has the email including IT systems highlighted with red. Over half of the data have email as a transfer tool at least in some point of the process. That is clearly an area to development.

Emails, text files and spreadsheets are usually almost totally manual information. With manually written information there is always a risk of misspelling. Also data with several steps transferred through the process and usually having one or two manually written phases in between is a risk. The more times the same information is written again and again the higher the risk of failure is.

Besides analysing the IT systems the information list was analysed by dividing the information into already existing and information that is created during the process. The divided list can be found in figure 23. For example customer requirements as well as line specific limitations classified as existing information. New information was thought to be for example the definition of the new product and the line parameters used to run the new product. On top of that some tacit knowledge was recognized in the workshops.

NEEDED DATA
Application / Wanted properties / Coating
Gloss
Colour reference
Annual tons / m2
Steel/substrate, width and thickness, tolerances
Protective film need
Customer information / contact details
Possibility to do the product
Status of the process
Colour matching criteria
Archiving number: D-number of ECI case number
Tolerances / Hold limits
Paints in use
Layers, painting order
Production line
Suitable back coats
MS number
Film thicknesses
Customer feedback
Chosen suppliers
Paint price, DSC%, density
Colour extra
Price of the product
E-number
Urgency
E-panel
E-panel acceptance
Information to production program & Sales Configurator
Product names, colour names
Marking
Production level / exemption
Spec number / Coating code
Product code (paint + colour + supplier combination)
Article number / Paint code
Supplier code (levnummer)
Colour code
Corresponding colour FIN/SWE
Tests to be done
Colour standard: visual and on spectrophotometer
Paint card
Coating card
Protective film type
Order information
Campaigns
Paint specification
Paint yield
Safety data sheets
Batch certificates: infinity values
Paint batch numbers
Raw material information
Settings from previous runs (roll speeds, roll pressures, oven temperatures)
Work instructions

Existing knowledge
Partly existing, but evaluated or adjusted during the process
New information created during the process
Critical information

Figure 23. Existing information, information created in the process and tacit knowledge containing information.

In figure 23 the darkest areas are existing information that is created somewhere outside the organization. The lighter blue areas are new information and the dotted parts are something in between. Those are information that has an existing preset, but can be defined again during the process. As it can be seen, most of the information that is present in the process is also created during the process.

From the list also critical knowledge was tried to recognize. Virtainlahti (2009) lists nine categories of what is critical knowledge:

- Knowledge tied to a certain occupation
- What knowledge does each of the persons have
- How are things handled
- Who knows best a certain duty
- Knowledge on the history of the company
- Customer knowledge
- Commercial practices in certain country
- Knowledge how to gather a team
- How to approach a problem

When dealing only with information the third and last bullet points are important here. It was defined in a workshop that most of the tacit information that has been found valuable is someone's experience and also product knowledge. Mainly the recognized critical information on the list is including tacit information on how things are handled, especially when there is a special case or a problem. Very likely there is much more tacit knowledge to be recognized, but this is a starting point.

The data and work flow diagram is in the form of traditional flow chart. Tasks are marked with boxes, decisions with diamonds and data with parallelograms. In the chart there are also three green boxes to mark the different stages of ECI. During the thesis project a decision was made to take an IT system called ECI into use. ECI is more thoroughly presented in chapter 6.2.1.

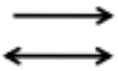
Symbol	Meaning
	Start or beginning
	Task or process
	Material, data, control or work flow
	Decision
	Document
	IT system or data storage
	Storage
	Data
	Waiting, lag

Figure 24. The main symbols of a process model. Attained from Martinsuo & Blomqvist (2010)

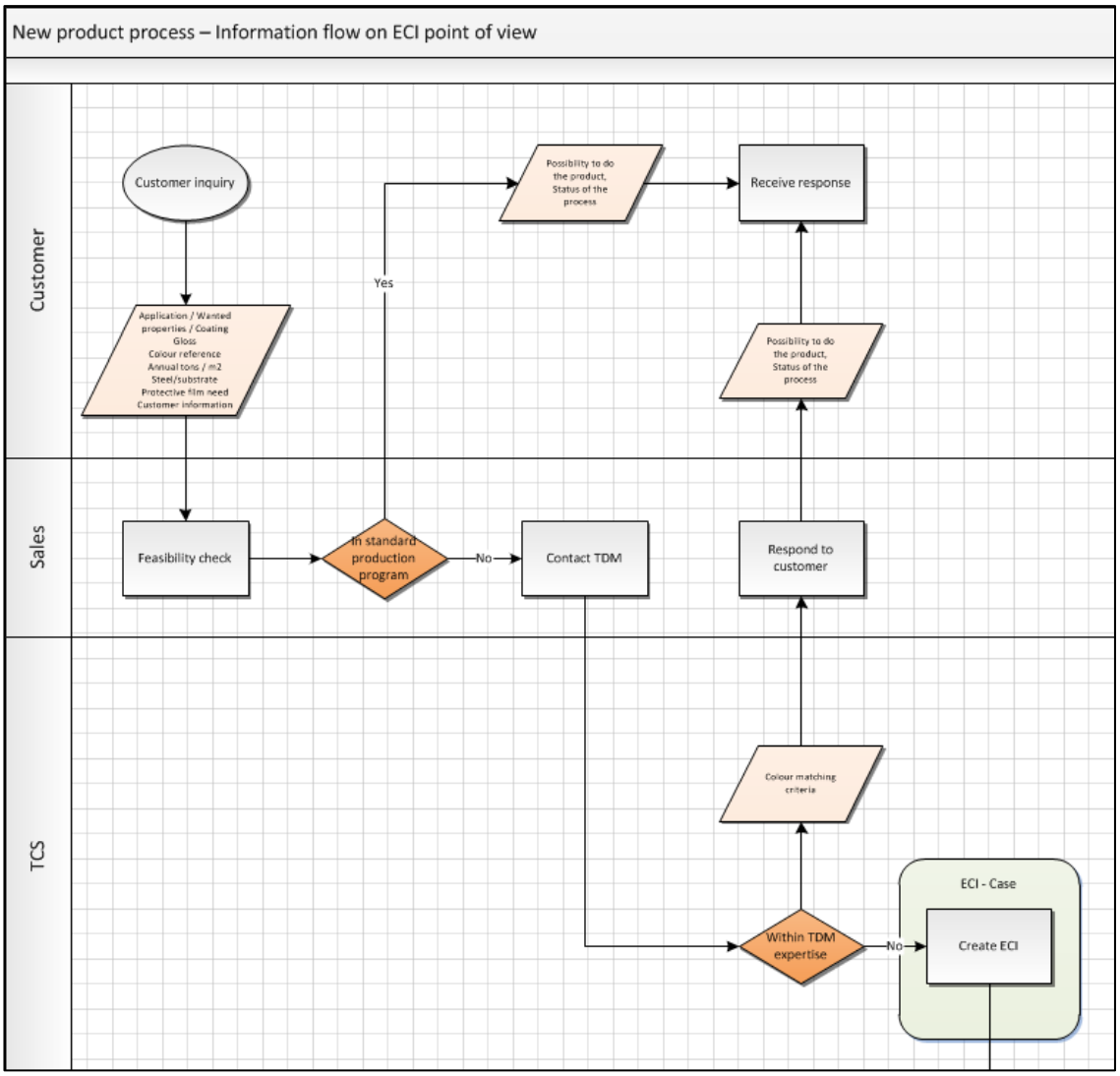


Figure 25. Part of the data and work flow diagram.

All in all DFD and the flow chart developed based on DFD are useful as they meet the quality system requirements. The models can also be used in initiation

6.2 Suggestions for development in the new product process

One of SSAB One's targets is to reduce loss. As presenter in chapter 2.1.1 the eight types of loss are overproduction, unnecessary movement, unnecessary storing, defects and redoing, unnecessary transportation, waiting, over processing and untapped creativity. (SSAB A 2017) Those principles are the base by which the development suggestions in this thesis are made.

The information that is needed in the process is challengingly in many different places. As the DFD in appendix A shows there are many organizations involved and the process has lot of stages. A customer has the knowledge on needs, but the knowledge on whether it is possible to produce is on paint supplier, product planning and production

among others. The data and work flow diagram also clearly presents in appendix B how information is transferred back and forth between different organizations.

First development suggestion is trying to simplify the email flow in the process by taking ECI into use with colour coated products also. As mentioned in the precious chapter the decision to start the ECI process was made during the research. The introduction of ECI would decrease the amount of email traffic, information would be saved systematically and easily accessible and every time in the same form. This would also effect on the first recognized tacit knowledge: possibility to do the product. The history data and the reasons behind the decisions would be saved into the system. During the workshops a lot of feedback was given concerning the transparency of the process which is also one pf Taghizadegan's (2013) theses. ECI would also increase that since all the organizations would have connection to it.

Despite the introduction of ECI there are still several cases that won't lead to ECI. There is a common email in use at product planning, but the actual mailbox is not used. The email address only forwards the emails to the employees' personal mailboxes. That causes all the historical data concerning decisions to be archived into personal inboxes that are not accessible by others. During last spring the policy was changed a bit. Nowadays the common mailbox is also on the recipient list when answering to emails. This way the answers are saved to other's inboxes as well. It still doesn't help is a new person is recruited. For that the suggestion is that there would also be the common mailbox available to use so that the new person would be able to go through some discussions from the history as well. That would decrease the risk of memory decay. Memory decay can happen when a key person is leaving the company, documentation is lost, or the knowledge is just not used enough to keep it in active memory. (Hislop 2005, De Holan et al. 2004)

Another suggestion for sharing the experience of the mode experienced employees is a common workspace for the product planning team. Separate workrooms immediately increase the mutual communication. In common workspace individual's own projects are often said out loud even if there is no specific reason for it and that is one part of sharing tacit knowledge. Key to saving tacit knowledge is social discussion and communication which is achieved for example through a lot of feedback, dialogue, mentoring, questioning and comparison (Virtainlahti 2009, Laamanen 2012).

One challenge and clearly a source of possible failure is the text document used to transfer information from product planning to product service and further to be updated into strip-SAP. The suggestion is to study whether it would be possible to print it out from ECI in the future. That would decrease one step of manually typing information from IT system to another. Another suggestion that would require much more resources would be transferring the order system into SAP in Finland too. The current Mainframe-based production system is not everlasting with continuously increasing number of items and

features. This way the IT systems structures would be generally the same between the two countries and the administration of the codes could be easier.

Production system is not the only differing IT system between the countries. There are different colour measurement systems and devices on half of the sites. Colour measurement is very sensitive operation and even two similar devices don't give exactly the same results. There has also been a very different policy on how to give colour codes and how to use colour standards in the companies before the merge. The situation has been faced especially when the corresponding colour pairs have been created. In one of the countries there has been quite wide scale on products that can have the same colour code and in the other it has been a lot narrower so the colours are not one-to-one corresponding. A common way of action has been set, but it is not fully in use, since it takes time to go through all the products and make standards for them. The situation is easier when there is a completely new colour, but it would be useful to have a written instruction how to define to corresponding colour code. On top of that a common colour measurement system with one common server would ease the work on both product planning and in production.

The last development suggestion concerns the information that is updated to production program and Sales Configurator. They both include huge amounts of information on the products. Updating the systems has been on one person's responsibility and includes quite much tacit knowledge on how to do it. This makes definitely critical information and at the same time it is probably the most challenging one to give development suggestions. The situation with the two tools became a lot more complicated after the merge when to different coding systems were combined into a system that was planned on the other only. There has been an improvement when a new common production program was launched. That is designed to work with both code systems. It also takes as much information as possible automatically from the IT systems, but there is still quite a lot of manually added information. The goal of the second phase of the common production program tool is to form a ready update file to be downloaded for SC, but that is still under development. The first suggestion for improvement is job circulation and initiating other team members to know at least the basics of the updating process. Now since the system is only in one place the second suggestion is to create a simplified work instruction to help through the main parts of the process and what special features are needed to consider. Problem with codification is that how to use the saved information efficiently Kirjavainen & Laakso-Manninen 2000). That is the instruction has to be planned to be as useful as possible.

On the list of recognized tacit knowledge there were chosen suppliers. There is an existing list of redundancy of the paint suppliers. However that list doesn't take a stand on the daily or monthly issues. The tacit knowledge in this case is knowledge on the workload of a certain paint supplier or other occasional problems. Either way it was found out not to be critical information, since it is not causing any extra trouble to send the in-

quiry to a busy supplier too. Creating a specification number or a coating code was noticed to have the same kind of status. There has been certain logic in creating the coating codes into Finnish systems, but over the time it has had to be given away. Nowadays the logic is only indicative and it is no harm to create a code that doesn't meet up the logic fully. So both of these data include tacit knowledge, but it was not felt necessary to be saved.

Common IT tools also increase the feeling of togetherness. Although it is four years since the merge the Sweden versus Finland division is still visible in many functions and working methods. The different IT systems are definitely not decreasing it. In the event, change acceptance and the success of organizational learning and tacit knowledge management depends on the motivation of individuals (Kirjavainen & Laakso-Manninen 2000, Ahmed et al. 2002, Senge 1994).

6.2.1 Design customer inquiry and exceptional customer inquiry tool

Current way of saving information of different new product process iterations is so called design colour inquiry. It is a spreadsheet based tool that has three parts: background data from customer, product planning's decisions and actions and lastly an information sheet to production. A part of the design colour inquiry is presented in figure 21.

Colour sample sent, date			
Difference to the colour, DE			
Final color code:		Select	
Production line:		Select:	
E-model/std sent to the line, date			
Added to M500			
Added to B550			
Added to B568			
Email to TS, Supply, Pricing, Product Manager			
Codes informed to paint supplier			
Added to New Color Product -excel			

Figure 26. Part of the current tool, design colour inquiry

So far the design colour inquiry has been working well enough. Since it is a spreadsheet file it is easy to modify and there is almost endlessly free space for comments, but it also has some cons. For example compilation of statistics is not that easy since the comments, that commonly are the most interesting part, can be located in any of the cells. The files are saved on product planning's file location which means that no one else has access to it. The design colour inquiry in its current form includes classified information and that way cannot be restored public.

The former APQP tool that was already mentioned in chapter 5.3 was in use at SSAB before the merge. A sample of part of the tool is presented in figure 22. The tool was used from up to bottom in order and the tool sent email to the next responsible person to make actions in the case.

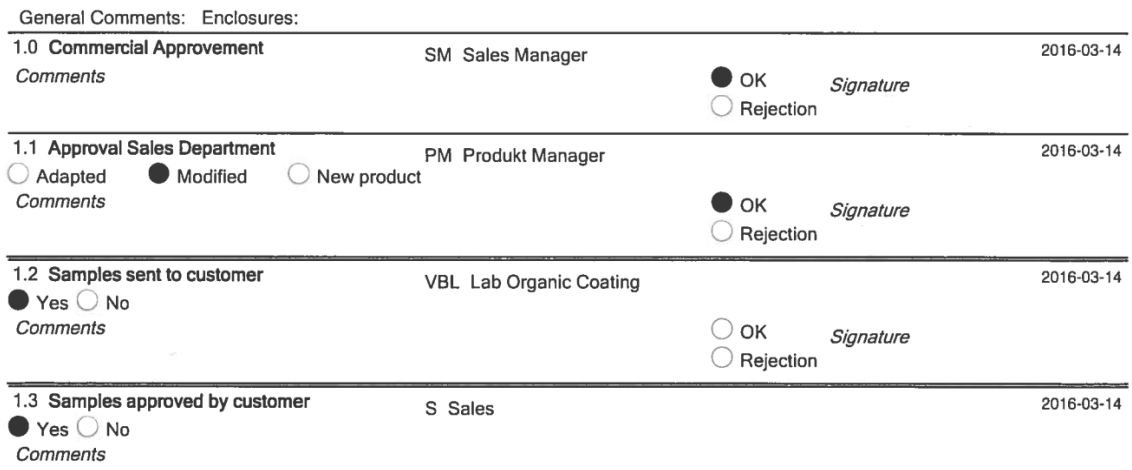


Figure 27. Part of the former APQP program

To that tool had all the organizations access and they could follow the process in real time. When design colour inquiry is highly variable the APQP tool had clear steps to follow. Downside of APQP tool was that it was quite formal. The emails the tool automatically sent were sometimes lost and forgotten during the vacation. It was also impossible to run the system lightly, meaning that it wasn't possible to use only parts of the steps.

Exceptional customer inquiry (ECI) is a tool under development. Some organizations already have been using it for several years, but for colour coated products it has not been used. The project for taking it into use is beginning. The goal for ECI is to be a combination of the two previously mentioned tools. It has been developed to provide quality response to customer for its request on products outside common production programme.

Sales, TCS, product management and product planning have access to ECI. Production has also their own interface that is mainly regarding productional questions. The tool has separated fields for classified information and accessible information that can be ruled to that certain organization sees only the information that concerning their tasks. Part of the configuration of ECI is presented in figure 23.

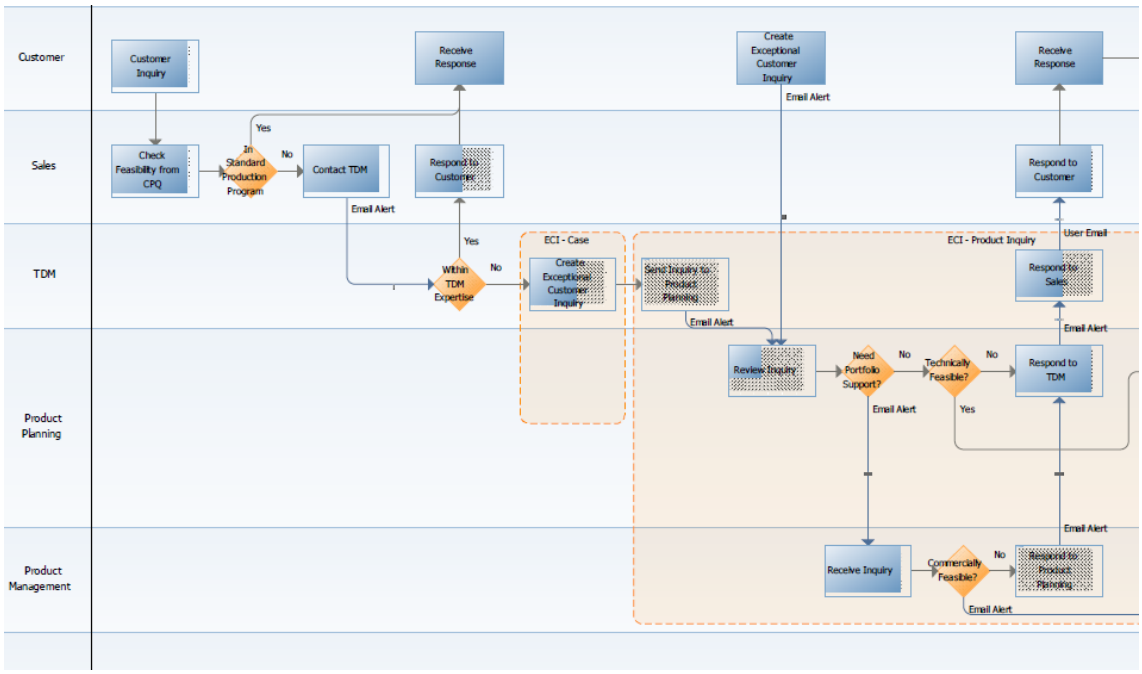


Figure 28. Part of ECI configuration

ECI also stores historical data and has a search tool that eases the checking whether the same modification or colour has been recently enquired. One goal in designing ECI is that there are enough free text fields so that the reasons behind the decisions could be defined and saved into the system.

CONTRIBUTION TO THE RESEARCH QUESTIONS

The analysis in chapters 6.1 contributes to the research question one by analysing the information that is generated during the new product process. It also answers to the first sub-question by explaining which organizations and IT systems are involved in the new product process.

The results in chapter 6.2 contribute to the second research question by giving concrete suggestions of how the new product process could be developed to get the critical tacit information saved.

7. DISCUSSION AND CONCLUSIONS

The goal of the research was to find the critical tacit information that is formed in new product process and to give a development proposal for developing the new product process to further the information transformation from tacit to explicit, to meet the principles of SSAB One and reducing the complexity of the new product process. Results and the analysis have been discussed in the last chapter so this chapter includes only the main research findings in the answers to problem setting. It also includes the evaluation of the study and proposals on continuation of research.

7.1 Answers to the problem setting

The objective set in chapter 2 was formulated into two main research questions and three sub-questions to ease the answering to the main questions. First the answers to the sub-questions:

What kind of information and IT systems and which organizations are involved in the new product process?

Involved organizations and IT systems can be found fully in the DFD in appendix A. The DFD was assembled in the workshops presented in chapters 3.2 and 6.1 and finalized by the researcher in cooperation with the participating organizations. All in all 14 organizations or quarters were found to be involved.

It systems were surveyed concerning one data at a time. The DFD lists for all the individual information the IT systems that it goes through and accumulates.

How can tacit information be transformed into explicit?

First, the tacit knowledge has to be recognized (Lönnqvist et al. 2005, Virtainlahti 2009, Järvenpää et al. 2016). The organization must also have communicative abilities to transfer the information (Lönnqvist et al. 2005). The next step is to define what is critical knowledge, why is it wanted to be saved, is it necessary to save and how it should be saved (Virtainlahti 2009, Järvenpää et al. 2016)

After the recognition and definitions a culture of valuing the information should be created. Competition between colleagues shouldn't be encouraged and the goal should be avoiding withholding knowledge. (Virtainlahti 2009)

There are basically two ways of transforming tacit knowledge into explicit: codification and personalization. First one is utilizing IT systems and the latter one uses communication and other social tools to transform the knowledge. (Hansen et al. 1999, Kirjavainen & Laakso-Manninen 2000, Hislop 2005)

How can a process model be utilized in creating a tacit information process?

Process models are used to increase understanding on the process, to ease analysing and decision making, developing the process or to develop a supporting system for the process. (Aguilar-Savén 2004, Martinsuo & Blomqvist 2010) Process model helps to recognize the problems, bottlenecks and development needs of a process. A process model can describe either knowledge flow, work flow, material flow or control flow or a combination of these (Lehtonen et al. 2012). Especially knowledge flow presents where the information emerges, where is it used, where it accumulates and what is the route of the information (Fujimoto 2007, Lehtonen et al. 2012) When knowledge flow in the process is recognized it is easier to find also the tacit knowledge sources and to define whether it is critical or not.

Now that the sub-questions have been answered the answers for the main research questions can be formed.

What kind of information is generated in different phases of the new product process?

In the DFD (appendix A) there are listed all the information that is present in new product process. From DFD a list was edited to visualize both existing information and information that is created during the process. The list is presented in figure 23.

In addition some tacit knowledge was able to be recognized concerning the process and also the critical parts of it. Majority of the information involved in the process is created during the process. Also some critical information was able to be recognized. Probably the most critical knowledge that was found was the production program and Sales Configurator updating.

How can the tacit information, which is generated during the process, be saved?

Chapter 6.2 presented six categories where development suggestions were given. One of the biggest suggestions was the introduction of ECI. The goal for ECI is to collect the colour matching and new product process data in the same place, reduce the amount of emails and increase transparency of the process.

To decrease the possibility of memory decay in product planning the next suggestion was the common email address. It is already used, but it is used only to forward messages automatically to individual's personal emails. If a new person is recruited into

product planning access to the old messages in the common email would ease independent working. Another suggestion to increase the shared experiences and knowledge would be a common workspace for the whole product planning team. Shared workspace would lower the threshold to ask and to share activities of the moment.

There is lot of manually typed information updates in the process. One of them is the route to update strip-SAP. First a text document template is filled in and based on that SAP is updated. This is not necessarily tacit knowledge, but it is definitely non-value adding. Lot of manual typing increases the probability of mistakes. Therefore it is suggested to add automation into the use of the text document. It should be studied whether it would be possible to get the file printed from ECI.

Colour standards, codes and measurement systems are quite challenging at the moment. Defining corresponding colour codes for Swedish and Finnish IT systems is a tricky part since there have been quite different policies in the companies before the merge. From this point of view a common colour measurement system would ease the process of colour standard management. The process of unifying the ways of actions is ongoing, but still not fully finished and until then it must be taken case by case.

The most critical and at the same time the most challenging information was the updating process of production program and a sales tool called Sales Configurator (SC). Nowadays it is only in hands of one person and includes a lot of information on the products. The development suggestion for this one was to arrange job circulation inside product planning and to write a simplified work instruction to support the updating.

As it was mentioned in the end of chapter 6.2 the most important thing to get the projects going is the motivation and interest of the employees.

7.2 Evaluation of the results and implementation of the study

This chapter evaluates whether the set goals have been reached and have the research questions been answered. On top that failure sources, novelty, validity and reliability are examined.

One failure source in this thesis is the researcher. Case study, especially like this, when the researcher works in the organization that is studied, is prone to be affected by the researcher's opinions and interpretations. The researcher also works in the organization that got the responsibilities of the discontinued organization. The opinions on the organizational changes can reflect to the opinions on the researcher too. The goal was to be as objective as possible, but some of the interpretations are unconscious.

According to Olkkonen (1994) the most common failure in using a questionnaire is that it is used before the theoretical part of the study is roughly together. It is too difficult to ask questions without knowing by self what would be the best questions and how are

the answers supposed to be used. The workshops were held at the same time as the theoretical part was collected. There were some parts that clearly needed revision and new questions afterwards. For example some organizations were added to the process model during the last weeks of this thesis. Finalizing the DFD also took several iterations to get it in the form that it is now.

The study is concentrating on only one process of one company. That way it is not entirely applicable to any other process, but the used theories and charts can be used as an example. Also the workshop participants have their personal opinions and attitudes that can effect on their part of the workshop. Everyone has their own way of communicating and the researcher just has to try to avoid misunderstandings.

Despite the failure sources and factors of uncertainty the research method was suitable for the case. The goal of the research was to study only this one process and it was not intended to get universally applicable results. This means that the validity of the research is a bit reduced. Validity means the ability of the chosen indicator to measure the object that was supposed to be measured in this research (Olkkonen, 1994). Although not providing universal results, the study still manages to reach the set goals give valuable results on the company point of view.

There are a lot of research on organizational learning and knowledge management and this thesis is part of it. It doesn't bring any significant surplus value or novelty to the field although it is valuable to the company in question. This thesis can still be referred as an example of how DFD can be utilized in developing a process other than software development.

The reliability of a study can be reviewed by answering the following questions (Saunders 2009):

- "Will the measures yield the same results on other occasions?
- Will similar observations be reached by other observers?
- Is there transparency in how sense was made from the raw data?"

The workshop working was one of the major data collecting methods in the study. The workshops are really situation related and subjective so it is not possible to repeat them as it is. The researcher is so close to the research object that it is possible that an external observer would get similar, but no exactly the same results. In a case study it is considerably more challenging consider the reliability of the results, since it's not possible for example to calculate margin of error (Olkkonen, 1994).

All in all, the thesis came out well and the feedback was positive. Research questions were reached and the research on the implementation of the suggested developments will continue from here.

7.3 Continuation of research

At the objective company the next step after this research is to study the given development suggestions and assess the possibilities to introduce them. The aim of this research was to survey targets of development and search for options and ideas to improve them. The final implementation and putting the changes into practice in the organizations are defined to be the company's responsibility after this study. Based on the findings of this research it is recommended to invest in finding and identifying critical tacit information and to create common lines of action for sharing and saving tacit information. This thesis considered mainly only one organization and one of its processes, but there are most likely other processes in the company that have the same starting points and problems.

It was relatively difficult to find from the literature practical examples of how learning organizations have been created and how tacit knowledge would be reasonable to save. Literature offered lot of suggestions how to start building a learning organization but there were less practical cases how the process has succeeded in practice and what problems have been confronted.

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APPENDIX A: DATA FLOW DIAGRAM

Original information source
Secondary information source
Tertiary information source
x Needs this information

CUSTOMER	SALES	TCS	PRODUCT PLANNING	PRODUCT SERVICE	PRODUCTION PLANNING	PAINT SUPPLIER	PRODUCTION: QUALITY TECHNICIANS / ENGINEERS	DELIVERY SUPPORT	SUPPLY CHAIN MANAGEMENT	PRODUCT MANAGEMENT	PRODUCT DEVELOPMENT	PROCESS DEVELOPMENT	MARKETING	NEEDED DATA	IT SYSTEM FIN	IT SYSTEM SWE
	x	x	x			x								Application / Wanted properties / Coating	email --> excel: D-form	email --> excel: D-form
	x	x	x			x								Gloss	email --> excel: D-form	email --> excel: D-form
	x	x	x			x								Colour reference	email --> excel: D-form	email --> excel: D-form
	x	x	x			x								Annual tons / m2	email --> excel: D-form	email --> excel: D-form
	x	x	x	x										Steel/substrate, width and thickness, tolerances	email --> excel: D-form	email --> excel: D-form
	x		x											Protective film need	email --> excel: D-form	email --> excel: D-form
	x	x	x											Customer information / contact details	email --> excel: D-form	email --> excel: D-form
			x			x								Urgency	email	email
x	x	x	x					x						Possibility to do the product	email --> excel: D-form	email --> excel: D-form
x	x	x						x						Status of the process	email	email
		x	x											Colour matching criteria	email	email
			x			x								Archiving number: D-number of ECI case number	email --> excel: D-form	email --> excel: D-form
			x											Line specifications	excel	excel
			x		x		x							Tolerances / Hold limits	IMS	MAS + Spec Admin
			x		x		x							Paints in use	IMS	MAS + Paint Admin
			x		x		x							Layers, painting order	IMS	MAS
			x											Production line	IMS	MAS + SAP
				x										Suitable back coats	-	email --> SAP + MAS
				x										MS number	-	email --> SAP
					x	x	x							Film thicknesses	IMS (+ email)	MAS + Paint Admin (+ email)
	x	x												Customer feedback	email	email
					x									Chosen suppliers	IMS	MAS + Paint Admin
			x		x				x					Paint price, DSC%, density	email --> excel: D-form	email --> excel: D-form
	x	x			x				x					Colour extra	email --> Sales Configurator --> SAP (by MDM team)	email --> Sales Configurator --> SAP (by MDM team)
x	x	x												Price of the product	email + Sales Configurator	email + Sales Configurator
						x								E-number	email	email
	x	x	x				x							E-panel / Colour model	-	-
	x	x	x											E-panel acceptance	email --> excel: D-form	email --> excel: D-form
		x	x											Information to production program & Sales Configurator	Remaster + Sales Configurator	Remaster + Sales Configurator
			x	x										Product names, colour names	email --> IMS	email --> SAP
			x	x			x							Marking	Lotus Notes	email --> SAP
			x	x										Production level / exemption	IMS	email --> SAP
x	x	x	x	x	x	x		x						Spec number / Coating code	IMS (+ email)	email --> MAS + SAP
					x	x			x					Product code (paint + colour + supplier combination)	IMS --> Arttu --> SAP	MAS + Paint Admin
			x		x									Article number / Paint code	IMS	MAS + Paint Admin
			x		x									Supplier code (levnummer)	IMS	Paint Admin
x	x	x	x	x	x			x	x					Colour code	IMS	email --> SAP + Paint Admin
			x	x				x						Corresponding colour FIN/SWE	IMS	email --> SAP
							x							Tests to be done	IMS	Spec Admin
						x	x							Colour standard: visual and on spectrophotometer	iColor	Colibri
			x		x		x							Paint card	IMS	-
					x		x							Coating card	IMS	-
			x	x	x									Protective film type	IMS / Lotus Notes	email --> MAS + SAP
	x	x			x		x	x						Order information	email --> IMS	email --> SAP
					x									Campaigns	excel: PISU	MAS
						x								Paint specification	email	email
					x									Paint yield	email --> IMS	MAS
							x							Safety data sheets	Chemsoft	Chemsoft
							x							Batch certificates: infinity values	email	email
							x							Paint batch numbers	email --> IMS	-
							x							Raw material information	IMS	MAS --> TVB
							x							Settings from previous runs (roll speeds, roll pressures, oven temperatures)	IMS	TVB
							x							Work instructions	Lotus Notes	APH

APPENDIX B: DATA AND WORK FLOW DIAGRAM